HUCs 10280101, 10280102, 10280103 – Grand River Watershed
Water body IDs: 593, 468, 457, 606, 608, and 610
Section 303(d) Listing: Escherichia coli

MISSOURI NATURAL RESOURCES

Voluntary Nonpoint Source Implementation Strategies

For

The Grand River watershed Total Maximum Daily Load

Worth, Gentry, DeKalb, Clinton, Harrison, Daviess, Caldwell, Ray, Mercer, Grundy, Livingston, Carroll, Putnam, Sullivan, Linn, Chariton, Nodaway, and Andrew Counties

Pollutant: *Escherichia coli* Bacteria

Completed: October 15, 2024

Prepared by: Water Protection Program, Watershed Protection Section

WATER BODY SUMMARY

Location: Worth, Gentry, DeKalb, Clinton, Harrison, Daviess, Caldwell, Ray, Mercer, Grundy, Livingston, Carroll, Putnam, Sullivan, Linn, Chariton, Nodaway, and Andrew Counties

8-digit Hydrologic Unit Codes (HUC):[1]
10280101 – Upper Grand
10280102 – Thompson River
10280103 – Lower Grand

Location of watershed in Missouri

12-digit HUC Subwatersheds
Multiple 12-digit HUC Subwatersheds

Water Body Identification Number (WBID) and Hydrologic Class:[2]
Grand River WBID (593), Class P
Middle Fork Grand River (468), Class P
East Fork Grand River (457), Class P
Locust Creek (606), Class P
East Fork Locust Creek (608 and 610), Class P and Class C

Designated Uses:[3]
Irrigation
Livestock and wildlife protection
Human health protection
Warm water habitat (aquatic life)
Whole body contact recreation category A (WBIDs 457, 593, 468, and 610)
Whole body contact recreation category B (WBIDs 606 and 608)
Secondary contact recreation
Drinking water supply (WBIDs 457, 593, and 606)

Impaired Use:
Whole body contact recreation category A (WBIDs 457, 593, 468 and 610)
Whole body contact recreation category B (WBIDs 606 and 608)
Secondary contact recreation (WBID 608)

Pollutants Addressed through TMDLs:
Escherichia coli (E. coli) (fecal indicator bacteria)

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[1] Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS 2019). A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).
[2] For hydrologic classes see 10 CSR 20-7.031(1)(E). Class P streams maintain permanent flow even in drought periods. Class C streams may cease flow in dry periods but maintain permanent pools which support aquatic life.
[3] For designated uses see 10 CSR 20-7.031(1)(F) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(F).

Length and Location of Impaired Segments:
Grand River (593): 56.0 miles, Mouth to Shoal Creek
Middle Fork Grand River (468): 27.5 miles, Mouth to Section 12, Township 66N, Range 31W
East Fork Grand River (457): 28.7 miles, Mouth to Section 29, Township 66N, Range 30W
Locust Creek (606): 91.7 miles, Mouth to State Line
East Fork Locust Creek (608): 16.7 miles, Mouth to Section 2, Township 62N, Range 20W
East Fork Locust Creek (610): 15.7 miles, Section 2, Township 62N, Range 20W to Section 12, Township 64N, Range 20W

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1. Introduction

This implementation strategies document is a companion to the total maximum daily load (TMDL) report for the Grand River, Middle Fork Grand River, East Fork Grand River, Locust Creek, and East Fork Locust Creek which addresses elevated *Escherichia coli* (*E. coli*) bacteria concentrations that resulted in these streams water bodies' placement on Missouri's Section 303(d) List of Impaired Waters. This implementation strategies document suggests actions that will reduce pollutant loading in order to meet the water quality goals established in the TMDL report. The TMDLs established for the impaired water bodies represent the *E. coli* loading capacity for each stream, which is the maximum amount of a pollutant that a water body can assimilate and still attain and maintain water quality standards. The goal of the TMDLs are to attain and maintain recreational uses in the water bodies. Additional watershed characteristics and *E. coli* loading targets can be found in the TMDL report, which is available on the Missouri Department of Natural Resources' website at: https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls. Questions regarding TMDLs may emailed to tmdl@dnr.mo.gov or by calling the Department's Watershed Protection Section at 573-751-5723.

This supplemental implementation document also addresses nutrient loading, although none of the water bodies addressed by the TMDL are currently identified as impaired for nutrients. This information is included because many of the suggested practices to reduce *E. coli* loading will also reduce nutrient loading. This information is provided for informational purposes only to guide watershed management planning activities and the implementation of best management practices (BMPs).

This document neither prescribes nor prohibits any specific practices or technologies for reducing pollutant loading in the impaired water bodies and is not intended to serve as a comprehensive plan or the sole means of remediation and restoration. The Department recognizes that technical guidance and support are critical to achieving the goals of any TMDL. Therefore, while the TMDL calculates the maximum pollutant loading that the impaired stream can assimilate and still attain and maintain water quality standards, this strategies document provides additional information to assist in meeting the TMDL loading goals including: pollutant reduction strategies, example calculations of pollutant reductions, potential participants in the watershed, and funding sources. The TMDL addresses pollutant loading from all potential sources in the watershed, however this strategies document is primarily intended to provide guidance for meeting nonpoint source loading targets.[4] The Department addresses point source pollutant reductions through the Missouri State Operating Permit program.[5]

Watershed management practices that reduce nonpoint source pollutant loading are conducted voluntarily by interested groups and landowners within the watersheds. In accordance with

[4] Point and nonpoint sources are defined and discussed in Sections 5.1 and 5.2 of the TMDL report for the Grand River watershed.

[5] The Missouri State Operating system is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES) program. The NPDES program requires all point sources that discharge pollutants to waters of the United States to obtain a permit. Issued and proposed operating permits are available online at https://dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees

Section 319 of the federal Clean Water Act, the U.S. Environmental Protection Agency (EPA) provides funding for nonpoint source pollutant load reduction practices. Section 319 nonpoint source subgrants are administered by the Department through Missouri's Section 319 program to assist organizations with watershed planning or implementation of activities as described in an accepted nine element watershed management plan (or alternative plan under certain specific conditions). The Nine Key Elements of a Watershed Management Plan are provided in Appendix A. More information on Missouri's Section 319 subgrant program is available at: dnr.mo.gov/water/what-were-doing/nonpoint-source-pollution-section-319. Potential partners and their possible roles for implementation are provided in Appendix B.

2. Watershed Characteristics

Grand River watershed is located in north central Missouri and south central Iowa (Figure 1). The Grand River (WBID 593) is formed by the Upper Grand River and Shoal Creek (WBID 518) merging together approximately 3 miles south of Chillicothe. The watershed is composed of three subbasins: the Upper Grand subbasin, the Lower Grand subbasin, and the Thompson subbasin. The Upper Grand subbasin is 3,325.95 square miles and is cataloged by the U.S. Geological Survey (USGS) as the 8-digit hydrologic unit (HUC) 10280101. The Lower Grand subbasin is 2,360.80 square miles and its 8-digit HUC is 10280103. The Thompson subbasin is 2,201.13 square miles and its 8-digit HUC is 10280102. The total watershed area draining to Grand River is approximately 7,888 square miles.

The Grand River watershed is located in the Rolling Loess Prairies EPA Level IV ecoregion (ecological subsection). Ecoregions are areas with similar ecosystems and environmental resources and are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing spatial differences in ecosystems, ecoregions stratify the environment by its probable response to disturbance (Chapman et al. 2002). Ecoregions are defined in Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(H). This ecoregion is named after its strongest feature, the thick loess deposits. Below the loess deposits are Pennsylvanian shales, limestones, and sandstone. This area is generally flat with an average gradient of 7.9 meter per kilometer (m/km). There are few springs and streams in this ecoregion are usually surface water dominated (MoRAP 2005).

Land cover types present in the Grand River watersheds are shown in Table 1. Figure 2 depicts the distribution of the land cover types throughout the watershed. Grassland and pasture areas potentially used for livestock grazing cover 44 percent of the Grand River watershed. Grassland and pasture cover 53 percent of the Middle Fork Grand River watershed, covers 48 percent of the East Fork Grand River watershed, covers 50 percent of the Locust Creek watershed, and covers 69 percent of the East Fork Locust Creek watershed.

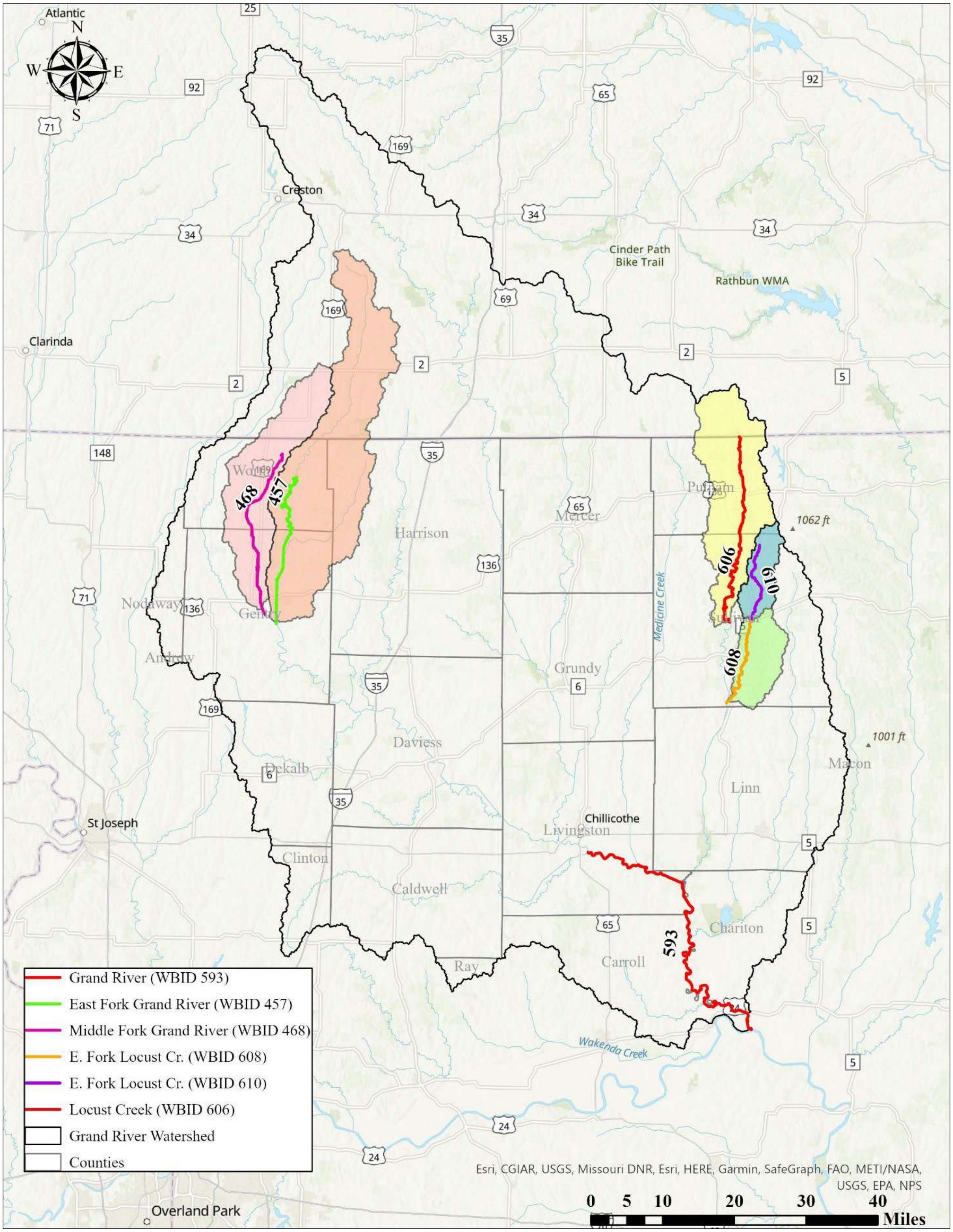

Figure 1. Location of the Grand River, Middle Fork Grand River, East Fork Grand River, Locust Creek, and East Fork Locust Creek Watersheds

Table 1. Land Cover in the Grand River watershed

Grand River (WBID 593)				
Land Cover Type	Total Watershed		Missouri Only	
	Area (mi²)	Percent	Area (mi²)	Percent
Developed, High Intensity	3.89	0.05%	3.31	0.05%
Developed, Medium Intensity	137.40	1.74%	99.82	1.62%
Developed, Low Intensity	22.66	0.29%	17.82	0.29%
Developed, Open Space	189.56	2.40%	158.04	2.57%
Barren Land	6.64	0.08%	5.92	0.10%
Cultivated Crops	2,388.64	30.27%	1,120.39	18.20%
Hay and Pasture	3,442.56	43.63%	1,791.76	29.10%
Scrub and Herbaceous	1,361.71	17.26%	2,682.01	43.56%
Forest	45.59	0.58%	16.43	0.27%
Wetlands	224.98	2.85%	207.40	3.37%
Open Water	66.41	0.84%	53.56	0.87%
Totals	7,890.04	100.00%	6,156.44	100.00%
Middle Fork Grand River (WBID 468)				
Land Cover Type	**Total Watershed**		**Missouri Only**	
	Area (mi²)	**Percent**	**Area (mi²)**	**Percent**
Developed, High Intensity	0.11	0.06%	0.06	0.04%
Developed, Medium Intensity	0.63	0.32%	0.32	0.23%
Developed, Low Intensity	3.67	1.85%	2.03	1.46%
Developed, Open Space	5.48	2.77%	4.00	2.87%
Barren Land	0.02	0.01%	0.00	0.00%
Cultivated Crops	50.21	25.37%	31.78	22.78%
Hay and Pasture	104.26	52.69%	72.82	52.19%
Scrub and Herbaceous	29.57	14.94%	25.28	18.12%
Forest	1.13	0.57%	0.89	0.63%
Wetlands	1.72	0.87%	1.44	1.03%
Open Water	1.10	0.56%	0.91	0.65%
Totals	197.87	100.00%	139.53	100.00%
East Fork Grand River (WBID 457)				
Land Cover Type	**Total Watershed**		**Missouri Only**	
	Area (mi²)	**Percent**	**Area (mi²)**	**Percent**
Developed, High Intensity	0.13	0.03%	0.10	0.04%
Developed, Medium Intensity	0.74	0.17%	0.44	0.16%
Developed, Low Intensity	5.91	1.37%	2.82	1.06%
Developed, Open Space	10.44	2.41%	7.42	2.78%
Barren Land	0.16	0.04%	0.05	0.02%
Cultivated Crops	117.98	27.25%	60.09	22.54%

Hay and Pasture	207.92	48.02%	125.30	47.00%
Scrub and Herbaceous	78.55	18.14%	62.15	23.32%
Forest	2.80	0.65%	2.10	0.79%
Wetlands	6.01	1.39%	4.75	1.78%
Open Water	2.37	0.55%	1.36	0.51%
Totals	433.00	100.00%	266.58	100.00%

Locust Creek (WBID 606)				
Land Cover Type	**Total Watershed**		**Missouri Only**	
	Area (mi^2)	**Percent**	**Area (mi^2)**	**Percent**
Developed, High Intensity	0.04	0.02%	0.04	0.02%
Developed, Medium Intensity	0.22	0.10%	0.93	0.54%
Developed, Low Intensity	1.67	0.75%	0.14	0.08%
Developed, Open Space	5.94	2.66%	4.96	2.85%
Barren Land	0.06	0.03%	0.06	0.03%
Cultivated Crops	43.32	19.42%	23.19	13.33%
Hay and Pasture	112.00	50.22%	91.69	52.70%
Scrub and Herbaceous	51.99	23.31%	45.96	26.42%
Forest	1.91	0.85%	1.63	0.94%
Wetlands	4.72	2.12%	4.39	2.52%
Open Water	1.16	0.52%	1.02	0.58%
Totals	223.03	100.00%	174.00	100.00%

East Fork Locust Creek (WBID 608,610)		
Land Cover Type	**Total Watershed**	
	Area (mi^2)	**Percent**
Developed, High Intensity	0.09	0.08%
Developed, Medium Intensity	1.68	1.35%
Developed, Low Intensity	0.32	0.26%
Developed, Open Space	3.60	2.89%
Barren Land	0.02	0.02%
Cultivated Crops	8.22	6.61%
Hay and Pasture	68.60	55.20%
Scrub and Herbaceous	36.98	29.75%
Forest	1.22	0.98%
Wetlands	2.11	1.70%
Open Water	1.45	1.17%
Totals	124.29	100.00%

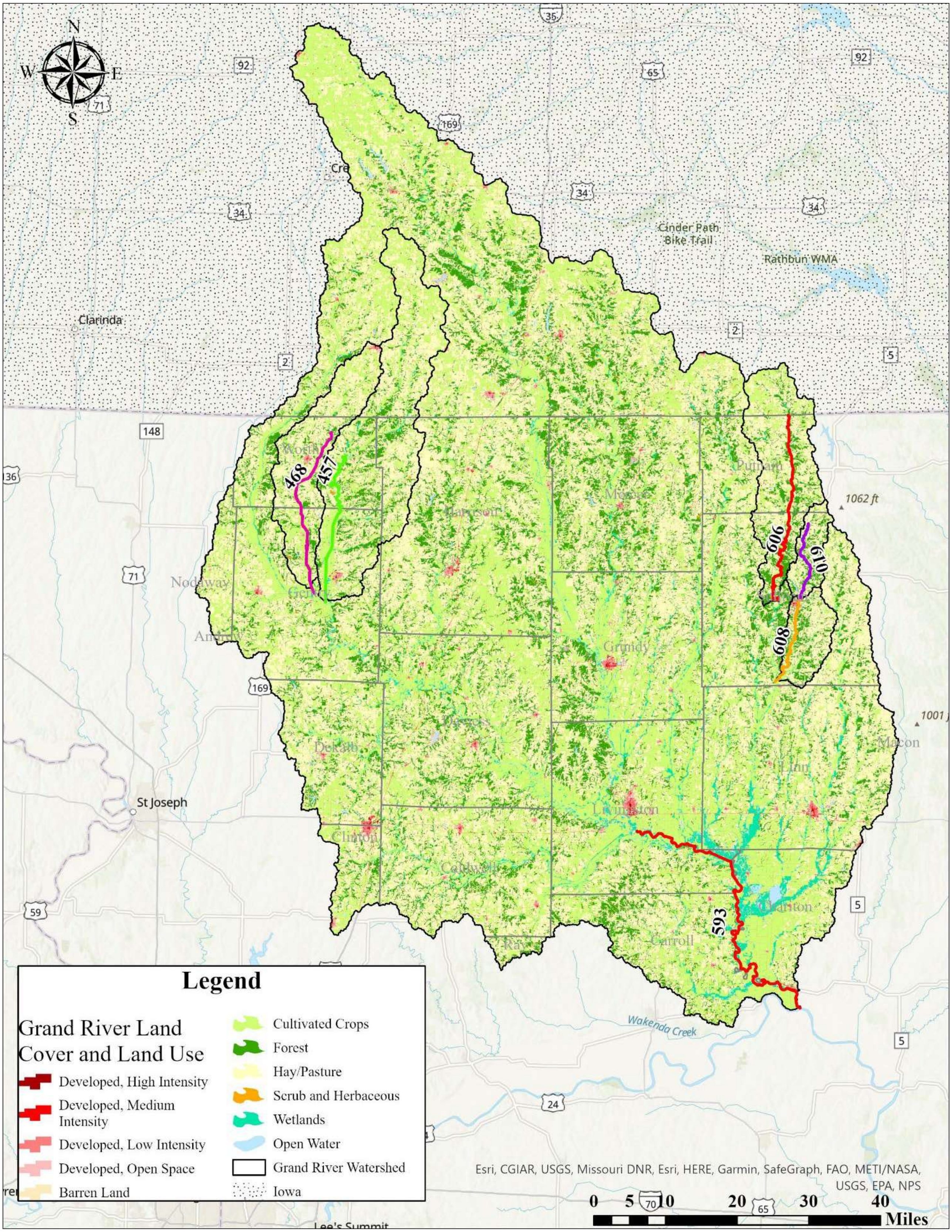

Figure 2. Land Cover in the Grand River Watershed

3. Water Quality Impairments

Water quality criteria represent a level of water quality that supports and protects designated uses. Specific numeric *E. coli* bacteria criteria are given in Missouri's Water Quality Standards at 10 CSR 20-7.031(5)(F) and Table A1. *E. coli* are bacteria found in the intestines of humans and warm-blooded animals and are used as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. For whole body contact recreation category A waters, *E. coli* concentrations during the recreational season (April through October) shall not exceed the geometric mean of 126 colony forming units (cfu) per 100 milliliters (mL) of water. For whole body contact recreation category B waters, *E. coli* concentrations during the recreational season shall not exceed the geometric mean of 206 cfu/100mL of water. For Secondary contact category waters, *E. coli* concentrations during the recreational season shall not exceed the geometric mean of 1,134 cfu/100mL of water.

Whole body contact recreation includes activities that involve direct human contact with waters of the state to the point of complete body submergence (10 CFR 20-7.031(1)(C)2.A.). During such activities, such as swimming, accidental ingestion of the water may occur and there is direct contact to sensitive body organs, such as the eyes, ears, and nose. Whole body contact category A applies to waters that have been established by the property owner as public swimming areas welcoming access by the public for swimming purposes and waters with documented existing whole body contact recreation uses by the public (10 CSR 20-7.031(1)(F)2.A.(I)). Whole body contact category B applies to waters designated for whole body contact recreation not contained within category A (10 CSR 20-7.031(1)(F)2.A.(II)). Secondary contact recreation, which includes activities such as boating, fishing, and wading, are activities that may result in contact with the water that is either incidental or accidental and the probability of ingesting appreciable quantities of water is minimal (10 CSR 20-7.031(1)(F)2.B.). The Department determines that a stream is impaired for *E. coli* bacteria when the water quality criteria are exceeded in any of the last three years for which there is a minimum of five samples collected during the recreational season. This approach is detailed in the Department's 2022 Listing Methodology Document, which is available online at: dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

In accordance with Missouri's 2022 Listing Methodology Document, the whole body contact recreation category A designated use for the Grand River, Middle Fork Grand River, East Fork Grand River, and East Fork Locust Creek (WBID 610); and the whole body contact category B uses for East Fork Locust Creek (WBID 608) and Locust Creek are impaired. The secondary contact recreational use is also impaired in a segment of East Fork Locust Creek (WBID 608). Sufficient data consistent with the assessment methodology are available to support these listings as summarized in Table 2. As shown, the Grand River *E. coli* concentrations exceeded the criterion in 2014-2016, 2018, and 2019, the Middle Fork Grand River *E. coli* concentrations exceeded the criterion in 2007, 2019, and the East Fork Grand River *E. coli* concentrations exceeded the criterion in 2017 and 2019, Locust Creek *E. coli* concentrations exceeded the criterion in 2012-2020, and East Fork Locust Creek *E. coli* concentrations exceeded the criterion in 2006, 2007, and 2018-2020. A summary of recreational season *E. coli* data used to assess water quality for the Grand River, the Middle Fork Grand River, East Fork Grand River, Locust Creek and East Fork Locust Creek are displayed in Table 2 and Figure 3.

Table 2. Summary of Recreational Season *E. coli* Data for the Impaired Water Bodies

Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
Grand River (WBID 593) Criterion = 126 cfu/100mL	2012	8	21	4,500	121.43
	2013	7	10	1,600	119.82
	2014	7	64	7,300	469.30
	2015	6	25	8,000	1,455.65
	2016	7	20	7,200	176.78
	2017	7	13	800	66.00
	2018	7	28	2,900	152.78
	2019	7	550	2,600	1,464.00
	2020	3	88	1,400	245.43
Waterbody (WBID)	**Recreation Season**	**Number of Samples**	**Minimum (cfu/100 mL)**	**Maximum (cfu/100 mL)**	**Geometric Mean (cfu/100 mL)**
Middle Fork Grand River (WBID 468) Criterion = 126 cfu/100mL	2007	5	270	770	438.39
	2009	4	200	120,000	2,103.66
	2010	4	67	15,000	618.70
	2011	4	210	23,000	911.00
	2012	3	120	18,000	654.53
	2013	4	36	530	152.03
	2014	4	190	24,000	941.17
	2015	4	170	33,000	2,593.13
	2016	4	120	28,000	2,290.40
	2017	4	790	2,100	1,268.36
	2018	4	580	43,000	1,866.26
	2019	5	95	62,000	1,537.31
	2020	25	37	14,000	372.55
Waterbody (WBID)	**Recreation Season**	**Number of Samples**	**Minimum (cfu/100 mL)**	**Maximum (cfu/100 mL)**	**Geometric Mean (cfu/100 mL)**
East Fork Grand River (WBID 457) Criterion = 126 cfu/100mL	2002	3	40	800	146.37
	2003	4	130	490	242.17
	2004	3	120	22,000	1,283.01
	2005	3	67	900	343.13
	2017	5	272	4,839	703.28
	2019	6	131	4,839	346.90

Waterbody (WBID)	Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
Locust Creek (WBID 606) Criterion = 126 cfu/100mL	2012	7	77	1,600	252.59
	2013	6	110	15,000	1,354.90
	2014	7	27	3,700	422.62
	2015	7	100	66,000	1,359.85
	2016	7	40	2,400	457.54
	2017	7	120	1,500	382.48
	2018	7	12	3,400	259.40
	2019	7	30	2,000	260.93
	2020	6	45	3,400	598.99
Waterbody (WBID)	**Recreation Season**	**Number of Samples**	**Minimum (cfu/100 mL)**	**Maximum (cfu/100 mL)**	**Geometric Mean (cfu/100 mL)**
East Fork Locust Creek (WBID 608) Criterion = 126 cfu/100mL	2006	5	365	1,986	715.00
	2007	10	816	4,484	1,223.91
	2018	11	65	4,839	599.20
	2019	11	344	4,839	2,598.41
	2020	12	461	4,839	2,127.51
Waterbody (WBID)	**Recreation Season**	**Number of Samples**	**Minimum (cfu/100 mL)**	**Maximum (cfu/100 mL)**	**Geometric Mean (cfu/100 mL)**
East Fork Locust Creek (WBID 610) Criterion = 126 cfu/100mL	2006	10	22	816	161.69
	2007	10	22	4,840	411.02

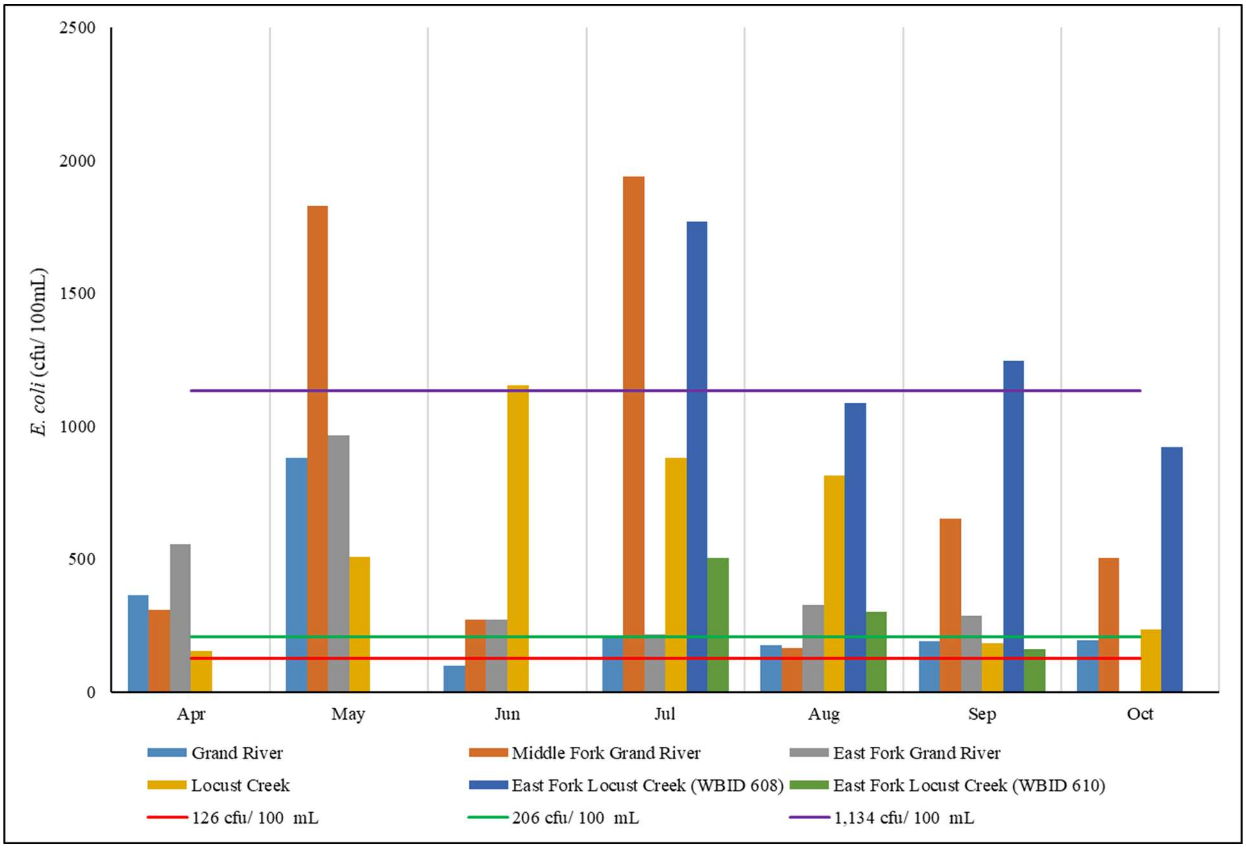

Figure 3. Geometric Means for *E. coli* by Month from 2002-2020

4. Causes and Sources of Pollutant Loads

Section 5 of the Grand River *E. coli* TMDL provides an inventory and assessment of all known and suspected sources of bacteria loading in those watersheds. The bacteria sources identified in the TMDL document are based on issued permits and a general knowledge of watershed conditions. TMDLs often lack data to identify specific *E. coli* contributions from specific nonpoint sources. Even so, all sources identified have the potential to contribute bacteria loading to surface waters and BMPs to reduce loading from those sources will provide overall water quality benefits to the impaired streams. Groups interested in implementing BMPs in the watershed may want to consider employing microbial source tracking techniques to better identify critical areas and to aid BMP selection. However, such techniques can be cost-prohibitive and may be unnecessary if localized land use activities or sources are already well known. More information regarding microbial source tracking techniques is available online from the USGS at: usgs.gov/labs/ohio-water-microbiology-laboratory/microbial-source-tracking.

4.1 Agricultural Areas

Croplands, pasturelands, and low-density animal feeding operations are potential sources of bacteria in surface waters. Bacteria are transported in runoff from areas fertilized with animal manure and where livestock are present. Runoff can result from precipitation or excessive irrigation. Section 640.760 Revised Statutes of Missouri (RSMo) establishes setback distances for surface application of liquefied manure from a Concentrated Animal Feeding Operation

(CAFO) by a third party.[6] Pursuant to Section 640.760 RSMo, the Department may enforce stricter setbacks. Soil and Water Conservation Districts provide funding and guidance for the development of nutrient management plans for private lands. Areas where nutrient management plans guide manure application and where best management practices are used to reduce soil erosion contribute less bacteria to surface waters than unmanaged areas. Although grazing areas are typically well vegetated, livestock tend to congregate near feeding and watering areas and create barren areas that are susceptible to erosion (Sutton 1990). Livestock that are not excluded from streams deposit manure and thus bacteria directly into waterways.

As shown previously in Table 1 and Figure 2, nearly seventy five percent of the Grand River watershed is covered by agricultural areas. This includes 3,442 square miles of hay and pasture potentially grazed by livestock. The exact type and number of livestock present in the Grand River, Middle Fork Grand River, East Fork Grand River, Locust Creek, and East Fork Locust Creek watersheds are unknown. The number of cattle in each watershed can be estimated from county cattle population numbers provided in the U.S. Department of Agriculture's 2017 Census of Agriculture (NASS 2017). Using the total number of cattle in the watershed counties and the proportion of the county's area of pastureland in the watershed to the total area of pastureland in the county, it is estimated that there are 318,422 cattle in the entire Grand River watershed.[7] Other types of livestock such as horses and sheep may also be contributing bacteria loads in the Grand River watershed. The number and distribution of other animals in the watershed cannot be estimated from available data. Due to the large proportion of land in the watershed used for agricultural purposes, agricultural stormwater runoff is a potential contributor of *E. coli* loading to the Grand River, Middle Fork Grand River, East Fork Grand River, Locust Creek, and East Fork Locust Creek.

4.2 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the attenuation of pollutants in runoff. Agricultural areas constitute approximately 17 percent of the riparian corridor land use of the TMDL streams in the Grand River watershed. These areas may be more susceptible to *E. coli* loading. Approximately 36 percent of the TMDL streams in the Grand River watershed riparian corridors are forested. This indicates that some *E. coli* transported from adjacent cropland and pasture lands into those areas may be intercepted before it enters the streams. Land cover within 100 feet of all streams in the Grand River watershed is presented in Table 3, land cover within the 100 foot buffer of impaired streams is presented in Table 4. Figures presenting the location of priority riparian corridors on the impaired streams are provide in Appendix D.

[6] Section 640.760 RSMo setback distances are: 50 feet from a property boundary, 300 feet from any public drinking water lake, 300 feet from any public drinking water intake structure, 100 feet from any perennial and intermittent streams without vegetation abutting such streams, and 35 feet from any perennial and intermittent streams with vegetation abutting such streams.

[7] This analysis assumes all areas identified as hay and pasture are being used for cattle grazing and that cattle are evenly distributed among those areas. Additionally, although some animals may be confined in some areas, for purposes of this estimation the entire cattle population was assumed to be grazing on pasture areas.

Table 3. Land Cover in the Riparian Corridor of the Total Grand River Watershed

Land Cover Type	Total Watershed		Missouri Only	
	Square Miles	Percent	Square Miles	Percent
Developed, High Intensity	0.04	0.01%	0.05	0.01%
Developed, Medium Intensity	0.44	0.11%	0.48	0.12%
Developed, Low Intensity	3.13	0.78%	3.00	0.77%
Developed, Open Space	5.04	1.25%	6.20	1.58%
Barren Land	0.53	0.13%	0.70	0.18%
Cultivated Crops	67.39	16.73%	54.09	13.80%
Grassland and Pasture	94.80	23.54%	85.45	21.80%
Scrub and Herbaceous	148.42	36.85%	161.41	41.19%
Forest	2.24	0.56%	2.19	0.56%
Wetlands	67.70	16.81%	65.09	16.61%
Open Water	13.02	3.23%	13.24	3.38%
Total	402.74	100.00%	391.89	100.00%

Table 4. Land Cover in the Riparian Corridor of the Impaired Streams in the Grand River Watershed TMDL

Land Cover Type	Total Watershed	
	Acres	Percent
Developed, High Intensity	1.29	0.03%
Developed, Low Intensity	5.83	0.15%
Developed, Medium Intensity	10.84	0.27%
Developed, Open Space	13.49	0.34%
Barren Land	47.79	1.20%
Cultivated Crops	334.89	8.42%
Hay/Pasture	260.36	6.54%
Shrub and Herbaceous	567.64	14.27%
Forest	12.53	0.31%
Wetlands	1,725.13	43.35%
Open Water	1,030.77	25.90%
Total	4,010.57	100.00%

4.3. Onsite Wastewater Treatment Systems

The Missouri Department of Health and Senior Services or a local onsite wastewater authority, typically the county health department, has jurisdictional authority for domestic wastewater treatment systems when the maximum daily flows of domestic wastewater is less than or equal to 3,000 gallons per day, for individual systems with subsurface soil dispersal serving a single family residence, and individual lagoons that serve no more than a single family residence. Most onsite wastewater treatment systems in Grand River, Middle Fork Grand River, East Fork Grand

River, Locust Creek, and East Fork Locust Creek watersheds are regulated by their respective County Health Department.

Properly functioning onsite residential wastewater treatment systems should not contribute significant amounts of *E. coli* to surface waters. Traditional septic systems are generally composed of several parts: tank(s) to contain liquid and allow settling of solids, a drainage (adsorption) field where liquid wastewater infiltrates the ground, and a filter to keep solids from entering the drainage field. All three of these parts must be in good order for a septic system to function properly. The removal of bacteria occurs mainly in the adsorption field by filtration and mortality. Failing systems, however, may be sources of bacteria during wet or dry weather. Factors that may make septic systems ineffective include age, inadequate land area, poor soil for drainage, high water table, and inadequate maintenance. Proper maintenance of onsite residential wastewater treatment systems including septic tanks, associated drain fields, and household lagoons should minimize bacteria loading to surface waters. Additional resources and EPA guide to septic systems may be found at: https://www.epa.gov/septic.

5. Existing Loads and Needed Reductions

TMDL targets are based on the applicable *E. coli* criteria for the protection of recreational uses in each stream. These targets are represented in Section 7 of the TMDL using load duration curves. Observed data are plotted on the load duration curve graphs to demonstrate the magnitude of existing loading and can be used to estimate the amount of pollutant reduction needed to meet the target and attain water quality standards. Points above the curve exceed the loading capacity and points on or below the curve are in compliance with water quality standards. The load duration curves also help to identify and differentiate between storm-driven loading and the presence of continuous loading. Storm-driven loading is expected under wet conditions when precipitation and runoff are high. Continuous loading is often evident at low flows when point source discharges have greater influence on water quality. When no point sources are present, low flow exceedances may be due to onsite wastewater treatment systems or livestock entering the stream. In the Grand River watershed, bacteria reductions are primarily needed during conditions above low flow conditions when stormwater influences are present. Therefore BMPs that address stormwater runoff will address the most significant sources of pollutant loading to the stream. Additional water quality monitoring conducted during watershed planning may help determine specific areas, or “hot spots,” where significant loading is occurring and where BMPs may be the most effective. Groups wishing to develop a monitoring component to any localized watershed plan are encouraged to consult with the Department’s Water Quality Monitoring and Assessment Unit, available at 573-522-4505.

5.1 *E. coli* Bacteria

The *E. coli* TMDLs for the Grand River, Middle Fork Grand River, East Fork Grand River, Locust Creek, and East Fork Locust Creek are represented by load duration curves that quantify the loading capacities of each water body at all possible flows. Tables 5 through 9 summarize the TMDLs at selected flows and the load reductions that are needed to meet the TMDL targets. The load reductions were calculated based on the geometric mean of observed *E. coli* data recorded during each selected flow regime. A geometric mean was used to remain consistent with Missouri’s *E. coli* criteria. As shown, *E. coli* concentrations do not exceed water quality criterion during all flow conditions.

Table 5. Grand River TMDLs and Needed Reductions

Percent of Time Flow is Equal or Exceeded[8]	Flow Condition	Median Flow (cfs)	TMDL (counts/day)	Existing Load (counts/day)	Needed Reduction (counts/day)	Needed Reduction (%)	Existing Concentration Geometric Mean
100-90	Low Flow	159	4.89E+11	1.77E+11	0.00E+00	0.00%	46
90-60	Dry Conditions	531	1.64E+12	5.78E+11	0.00E+00	0.00%	44
60-40	Mid Range	1,553	4.79E+12	5.53E+12	7.41E+11	13.41%	146
40-10	Moist Conditions	4,865	1.50E+13	2.01E+14	1.86E+14	92.53%	1,686
10-0	High Flow	32,545	1.00E+14	3.87E+15	3.77E+15	97.41%	4,862

Table 6. Middle Fork Grand River TMDLs and Needed Reductions

Percent of Time Flow is Equal or Exceeded	Flow Condition	Median Flow (cfs)	TMDL (counts/day)	Existing Load (counts/day)	Needed Reduction (counts/day)	Needed Reduction (%)	Existing Concentration Geometric Mean
100-90	Low Flow	1.32	4.08E+09	7.10E+09	3.02E+09	42.55%	219
90-60	Dry Conditions	9.26	2.85E+10	6.88E+10	4.03E+10	58.53%	304
60-40	Mid Range	28.62	8.82E+10	3.15E+11	2.26E+11	71.95%	449
40-10	Moist Conditions	95.06	2.93E+11	5.34E+12	5.04E+12	94.51%	2,295
10-0	High Flow	676.20	2.08E+12	4.52E+14	4.50E+14	99.54%	27,301

Table 7. East Fork Grand River TMDLs and Needed Reductions

Percent of Time Flow is Equal or Exceeded	Flow Condition	Median Flow (cfs)	TMDL (counts/day)	Existing Load (counts/day)	Needed Reduction (counts/day)	Needed Reduction (%)	Existing Concentration Geometric Mean
100-90	Low Flow	2.92	8.99E+09	0.00E+00	0.00E+00	0.00%	0
90-60	Dry Conditions	20.41	6.29E+10	2.06E+11	1.43E+11	69.43%	412
60-40	Mid Range	63.07	1.94E+11	1.65E+11	0.00E+00	0.00%	107
40-10	Moist Conditions	209.52	6.46E+11	1.13E+13	1.06E+13	94.26%	2,195
10-0	High Flow	1,490.40	4.59E+12	8.97E+13	8.51E+13	94.88%	2,460

[8] The percent of time flow is equaled or exceeded is a statistical measure used to divide the load duration curve into flow ranges that are indicative of low flow, dry conditions, mid range, moist conditions, and high flows. For example, a 10 percent value indicates a high flow that only occurs or is exceeded 10 percent of the time.

Table 8. Locust Creek TMDLs and Needed Reductions

Percent of Time Flow is Equal or Exceeded	Flow Condition	Median Flow (cfs)	TMDL (counts/day)	Existing Load (counts/day)	Needed Reduction (counts/day)	Needed Reduction (%)	Existing Concentration Geometric Mean
100-90	Low Flow	1.51	4.66E+09	2.79E+09	0.00E+00	0.00%	75
90-60	Dry Conditions	10.58	3.26E+10	6.04E+10	2.77E+10	45.96%	233
60-40	Mid Range	32.70	1.01E+11	7.18E+11	6.17E+11	85.96%	897
40-10	Moist Conditions	108.64	3.35E+11	1.93E+12	1.60E+12	82.68%	728
10-0	High Flow	772.80	2.38E+12	1.84E+14	1.81E+14	98.70%	9,719

Table 9. East Fork Locust Creek TMDLs and Needed Reductions

Percent of Time Flow is Equal or Exceeded	Flow Condition	Median Flow (cfs)	TMDL (counts/day)	Existing Load (counts/day)	Needed Reduction (counts/day)	Needed Reduction (%)	Existing Concentration Geometric Mean
100-90	Low Flow	0.84	2.58E+09	1.93E+10	1.68E+10	84.86%	945
90-60	Dry Conditions	5.86	1.81E+10	1.19E+11	1.01E+11	84.86%	832
60-40	Mid Range	18.10	5.58E+10	5.56E+11	5.00E+11	89.96%	1,255
40-10	Moist Conditions	60.14	1.85E+11	5.21E+12	5.03E+12	96.44%	3,544
10-0	High Flow	427.80	1.32E+12	--	--	--	--

6. Implementation

Pollutant reductions from nonpoint sources to improve water quality are dependent upon voluntary actions and support from local communities and landowners in the watershed. The strategies described in this document are intended as guidance to local governments, regional planning commissions, private landowners, and citizen groups for achieving the load allocations targets established in the TMDL. This guidance does not establish any new legal requirements or costs upon any landowner for controlling nonpoint sources.

6.1 Nonpoint Source Management Activities Previously Implemented

The Missouri Soil and Water Conservation Program provides cost-share for a variety of BMPs that support reductions of *E. coli* loading from agricultural lands. Many soil and water conservation management practices that reduce erosion also reduce *E. coli* and nutrient loading. In addition, livestock exclusion, livestock feeding practices and pasture management practice (terracing, grass waterways, etc.) may assist with *E. coli* load reduction. Table 10 summarizes the types of practices implemented in the Grand River watershed between 2018 and 2022.

Table 10. 2018-2022 Soil and Water Conservation Practices in the Grand River Watershed by HUC 8[9]

HUC 8	Conservation Practice	NRCS Practice Code	# of Practice per HUC 8
10280101	Permanent Veg. Cover Establishment	DSL-01	86
10280102			39
10280103			23
10280101	Terrace System	DSL-04	10
10280103			1
10280101	Diversion	DSL-05	75
10280102			16
10280103			6
10280101	Permanent Veg. Cover - Critical Area	DSL-11	12
10280102			2
10280103			1
10280101	Terrace System with Tile	DSL-44	423
10280102			134
10280103			179
10280101	Grazing System Water Development	DSP 3.1	10
10280103			1
10280101	Grazing System Water Distribution	DSP 3.2	13
10280102			3
10280103			2
10280101	Grazing System Fence	DSP 3.3	16
10280102			3
10280103			2
10280101	Permanent Veg. Cover Enhancement	DSP-02	4
10280103			2
10280101	Water Impoundment Reservoir	DWC-01	222
10280102			111
10280103			195
10280101	Sediment, Erosion, Water Control Structure	DWP-01	90
10280102			77
10280103			42
10280101	Sod Waterway	DWP-01	35
10280102			3
10280103			6
10280101	Cover Crop	N340	1635
10280102			435
10280103			484

[9] Additional information regarding soil and water conservation cost-share practices in Missouri is available online at: https://dnr.mo.gov/land-geology/businesses-landowners-permittees/financial-technical-assistance/soil-water-conservation-cost-share-practices.

10280101	Waste Management	N312	1
10280101	Field Border	N341	1635
10280102			435
10280103			484
10280101	Filter Strip	N386	5
10280101	Livestock Exclusion	N472	19
10280102			8
10280103			39
10280101	Stream Protection	N472	3
10280102			9
10280103			4

6.2 Potential Nonpoint Source Management Measures and Expected Load Reductions

Examples of nonpoint source management measures are summarized in the following sections. In addition to agricultural BMPs, appropriate care and maintenance of onsite wastewater treatment systems is expected to provide additional pollutant reductions to the impaired streams.

6.2.1 Riparian Buffers

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in erosion reduction, as well as the detention, removal, and assimilation of pollutants in runoff. Therefore, a stream with good riparian cover is better able to mitigate the impacts of high pollutant loads than a stream with poor or no riparian cover. Shade provided by riparian corridors is also important because it helps to keep water cooler (cold water holds more oxygen) and reduces temperature variation that stresses aquatic life especially during the critical low flows that typically occur in July and August. Riparian corridors that lack woody vegetation should be prioritized for riparian restoration. Appendix E displays these priority riparian corridors in red.

6.2.2 Streambank Stabilization

Streambank stabilization measures also reduce erosion. Such measures may include the installation of live stakes, coconut fiber rolls and mesh, coir rolls, bank terracing, large woody debris, and large boulders to support streambanks and reduce erosion. Integrating shrub and tree planting with other bank stabilization measures results in long-term stabilization as the

vegetative roots expand and provide further soil stability. Many resources are available to guide streambank stabilization design for specific conditions. A good initial reference is the *Army Corps of Engineers Streambank and Shoreline Protection Manual* (https://www.lrc.usace.army.mil/Portals/36/docs/regulatory/pdf/StrmManual.pdf). A study of bank stabilization on the Cedar River in Nebraska found the average streambank erosion rate before stabilization was approximately 1.5 ft^2/ft. and was reduced to 0.5 ft^2/ft. after stabilization measures were implemented (Naisargi and Mittelstet 2017). [10]

6.2.3 Livestock Exclusion

Livestock that have access to streams reduce streamside vegetation, increase barren areas, and contribute *E. coli* and nutrients directly to streams. In addition, compaction from animals contributes to poor quality aquatic habitat because the interstitial spaces in stream substrate are eliminated. Excluding livestock from streams is another way to improve water quality and aquatic habitat in the Grand River, Middle Fork Grand River, East Fork Grand River, Locust Creek, and East Fork Locust Creek watersheds.

[10] The Cedar River watershed is located in North Central Nebraska. The western half of the watershed is mainly grassland and sand dunes in the Sand Hills, whereas the eastern half is predominantly cropland.

6.2.4 Nutrient Management

Nutrient management is an effective strategy for reducing *E. coli* and nutrient loading from agricultural lands to streams, and is especially important in Grand River watershed due to the amount of land cover classified as pasture/hay in the watershed. The *Missouri Concentrated Animal Feeding Operation Nutrient Management Technical Standard* is available online at: dnr.mo.gov/document-search/missouri-concentrated-animal-feeding-operation-nutrient-management-technical-standard-march-4-2009. The technical standard describes soil and manure testing protocols, manure application criteria including required setback distances from streams, and monitoring requirements.

The primary goal of nutrient management is to promote biomass productivity that provides profit for producers while minimizing negative environmental impacts. Over-application of nitrogen and phosphorus above the crop needs will cause these nutrients to accumulate in the soil and increase the potential for losses to the environment. Nutrient management planning minimizes the transport of *E. coli*, nitrogen, and phosphorus to surface water and groundwater by optimizing fertilizer application rates, timing, and placement, as well as accounting for all sources of nutrients.

Nutrient management plan development may be eligible for cost-share through the Soil and Water Conservation Program. Nutrient Management Plans should be developed in accordance with the Natural Resources Conservation Service (NRCS) Standards and Specifications for Nutrient Management (Code 590). Landowner assistance is available through local County Soil and Water Conservation Districts.

In general, the following are required to begin nutrient management planning:

- Soil samples, based on a 7-inch depth, taken once every 4 years, as a minimum, to monitor the phosphorus, potassium, pH, and organic matter levels and adjust nutrient application rates as needed. The pH of the soil is important because it has a direct effect on nutrient availability. Iowa State University gives recommendations and soil testing procedures to develop a crop budget for determining crop nutrient needs. Nitrate testing using the late spring nitrate test and fall corn stalk test can be used to monitor the nitrogen management program. Soil pH levels shall be maintained near 6.5 for corn and soybeans and 6.9 for alfalfa.
- Manure analysis could be completed on an annual basis for percent of solids, total Nitrogen (N), organic N, Ammonium (NH_4), Phosphorus Pentoxide (P_2O_5), Potassium Oxide (K_2O), and pH. A more realistic nutrient content can be obtained by using the averages of three or more analysis.
- Soil tests and realistic yield potentials will be used to determine the application rate of manure so as to supply most of the crop nutrient needs through the manure and legume credits. No additional commercial phosphate or potash will be applied on soils testing high or very high in phosphorus and potassium. On these fields, additional commercial nitrogen will

be applied as needed. This will optimize crop yield potential while minimizing nutrient runoff and nitrogen leaching.

- Sensitive areas: Commercial nutrients, manure and organic by-products should not be applied to frozen, snow covered ground or saturated soil on slopes greater than five percent unless erosion is controlled. Manure and organic by-products should not be applied within 200 feet of a stream, lake, agricultural drainage well, or sinkhole unless injected or incorporated within 24 hours.
- Risk Analysis: The phosphorus index will be used to determine fields that are a high risk for phosphorus losses. Conservation and/or management practices will be used to reduce the potential for phosphorus movement off site. Soil tests will be taken every 4 years to determine changes in phosphorus levels.

The plan should receive periodic review to determine if adjustments or modifications are needed. At a minimum, the plan will be reviewed and revised with each soil test cycle.

6.2.5 Cover Crops

Planting cover crops rather than leaving cultivated cropland barren has both economic and environmental benefits. Legume cover crops can reduce fertilizer costs because of their symbiotic relationship with soil bacteria. Specific bacteria reside within the nodules on the roots of legumes such as vetch and clover and convert nitrogen gas from the atmosphere into soil nitrogen that crops can use. This biological nitrogen fixation reduces the amount of fertilizer that needs to be purchased and applied. Applying less manure or fertilizer to the topsoil means reduced transport of *E. coli* or nutrients to water bodies in the watershed. Cover crops also reduce erosion by holding soil in place and reducing top-soil crusting. Reducing runoff is expected to reduce overall contributions of *E. coli* loading from cropland to surface waters. The plant material left behind after cover-cropping increases water infiltration and reduces evaporation. This reduces the amount of nutrient-laden runoff, and the amount of water needed for irrigation. Moisture retention by decaying plant material also helps soils be more resilient to periodic drought conditions.

A study conducted by Zhu et al. (1989), as cited in Sharpley and Smith (1991), found that planting common chickweed, Canada bluegrass, and downy brome on Missouri soybean fields decreased water runoff by an average 44 percent. The study found that nitrogen (as nitrate) loss was reduced by an average 75 percent and soluble phosphorus runoff was reduced by an average 37 percent. Sharpley and Smith (1991) found that planting ryegrass or wheat on peanut crops for 6 months of the year reduced soil loss by an average of 83 percent.

6.2.6 Prairie Strips

Implementing prairie strips in croplands can reduce both soil erosion and nutrient runoff. Prairie strips include edge-of-field filter strips and infield contour buffer strips. Infield contour buffer strips' primary purpose is to reduce erosion, while edge of the field filter strips primary purpose is to filter excess nutrients and animal waste. A study conducted in Iowa found that converting 10 percent of crop field to prairie filter strips reduced average annual nitrate, total nitrogen, and total phosphorous concentrations by 35, 73, and 82 percent respectively (Zhou et al. 2014). Reductions in erosion are expected to result in reduced *E. coli* loading to surface waters.

6.2.7 Field Borders

Field borders can provide a number of conservation benefits, such as reducing soil erosion from wind and water, protecting soil and water quality and providing habitat for wildlife. These habitats, located at the edges of crop fields, can also serve to connect other buffer practices and habitats within the agricultural landscape. The U.S. Department of Agriculture's Farm Service Agency (FSA) runs a program called the Continuous Sign-up Conservation Reserve Program (CCRP) that provides farmers with rental payments on land set-aside for conservation buffers for a period of 10 to15 years. Cost-share payments may also be available to help farmers with the financial burden of establishing the buffers.

6.2.8 Public Outreach

Public outreach is a key component of any watershed-based plan. Support for nonpoint source reduction plans is generated through education and outreach activities designed to inform the public about water quality issues and what can be done to reduce pollutant loading in watersheds. The following are some activities that may be implemented to develop support and participation for watershed stewardship:

1. Hold meetings and other outreach events to inform private landowners of the available technical support and financial incentives for implementing pollutant reduction strategies.

2. Attend livestock auctions and demonstrations in the local community, and hand-out literature explaining the available technical support and financial incentives for implementing pollutant reduction strategies.

3. Develop small-scale demonstrations of pollutant reduction strategies.

4. Implement a public awareness campaign regarding water quality with public service announcements.

5. Host local watershed festivals.

6.2.9 Onsite Wastewater Treatment System Repair and Maintenance

Failing onsite wastewater treatment systems (e.g., septic systems) may be sources of bacteria to nearby waterways during periods associated with either wet weather or dry weather flows depending upon the nature of the failure. By design, properly functioning onsite wastewater treatment systems should not be contributing significant bacteria or nutrient loads to surface waters. For this reason, the TMDL assigns a load allocation of zero to these potential sources. Proper maintenance of onsite wastewater treatment systems including septic tanks, associated drain fields, and household lagoons is the primary BMP for limiting bacterial inputs from these sources. Educating homeowners about proper onsite wastewater treatment system maintenance may be provided by local health departments, watershed groups, or university extension offices. The EPA maintains various guidance documents and resources pertaining to onsite treatment systems online at: https://www.epa.gov/septic. For onsite wastewater treatment systems that are already failing, repair or replacement of the system is necessary. Any local ordinances regarding permitting requirements pertaining to repairs, replacement or the installation of new systems must be followed. Consideration should be given to reducing reliance on onsite systems in favor of centralized systems. Homeowners and local governments should explore the potential elimination of onsite systems and connection to existing sewer systems. Elimination of any onsite wastewater treatment systems in the watershed is expected to result in reductions of bacteria loading.

7. Measurable Milestones

Measurable milestones outline time frames for the incremental implementation of pollutant reduction strategies. Attainable milestones should be established based on available funding and stakeholder participation. Watershed-based plans should include milestones for public outreach, attaining funding, and the implementation of chosen nonpoint source management measures. Plans that are developed to procure Section 319 subgrants must be renewed every five years to stay eligible for funding. It is therefore good general practice to develop measurable milestones on 5-year timeframes. Periodic evaluations allow for an adaptive management approach that makes progress towards water quality goals, while using any new data and information to reduce uncertainty and adjust implementation activities. The following is an example of measurable milestones over a 20 year timeframe.

5-Year Milestones

- Conduct outreach, gain public participation, and explore funding options that will allow pollutant reduction strategies to be implemented.
- Develop a comprehensive watershed management plan and identify key areas for implementation.
- Procure funding and begin implementing strategies such that:
  - Nutrient management plans are developed and implemented on 10 percent of unregulated agricultural lands in the watershed, and
  - Riparian buffers, and fencing protects 10 percent of tributaries to the impaired waters.

  - 2 percent of streambanks are stabilized in key areas.
- Complete annual monitoring and adaptive management to assess the effectiveness of streambank stabilization projects and to ensure that all newly established riparian buffers are progressing toward maturity.

10-Year Milestones

- Continued outreach, public participation, and funding procurement.
- Develop and implement nutrient management plans on 25 percent of unregulated agricultural lands in the watershed,
- Construct riparian buffers, and fencing to protect 25 percent of tributaries to the impaired waters,
- Construct streambank stabilization in 5 percent of key areas, and
- Complete annual monitoring and adaptive management to assess the effectiveness of streambank stabilization projects and to ensure that all previously established riparian buffers are intact and newly established riparian buffers are progressing toward maturity.

15-Year Milestones

- Continued outreach, public participation, and funding procurement.
- Develop and implement nutrient management plans on 50 percent of unregulated agricultural lands in the watershed,
- Construct riparian buffers, and fencing to protect 50 percent of tributaries to the impaired waters,
- Construct streambank stabilization in 7 percent of key areas, and
- Complete annual monitoring and adaptive management to assess the effectiveness of streambank stabilization projects and to ensure that all newly established riparian buffers are effectively attenuating pollutants.

20-Year Milestones

- Continued outreach, public participation, and funding procurement.
- Develop and implement nutrient management plans on 75 percent of unregulated agricultural lands in the watershed,
- Construct bank stabilization, riparian buffers, and fencing to protect 75 percent of tributaries to the impaired waters,
- Construct streambank stabilization in 10 percent of key areas, and
- Complete annual monitoring and adaptive management to assess the effectiveness of streambank stabilization projects and to ensure that all previously established riparian buffers are intact and newly established riparian buffers are progressing toward maturity.

8. Cost-Benefit

Cost-benefit analyses can be conducted during the watershed management planning process to determine the most efficient investments of time, effort, and supplies. Costs associated with nutrient management plan implementation and cover crops are relatively minimal because many of the practices are already integrated into the farming system and substantial cost savings are achieved through reducing the need for manure application and chemical fertilizers. Streambank

stabilization is the most expensive pollutant reduction strategy but can be limited to key areas to stabilize highly erosive streambanks for the benefit of water quality in all downstream waters.

9. Potential Government Assistance and Funding

Reducing pollutant loading to achieve TMDLs often requires participation and technical support from government agencies. Public service staff can often provide technical guidance and direct interested parties to potential funding sources. Some of the available agencies and organizations and their potential roles, including funding avenues, are listed in Table 11. The list is not exhaustive. The most commonly used sources of funding are low-interest loans through the State Revolving Fund to implement point source goals, Section 319 subgrants, and Soil and Water Conservation Program cost-share practices.

Table 11. Agency Roles and Funding Options

Agency and Roles	Funding Options
US Department of Agriculture, Natural Resources Conservation Service https://www.nrcs.usda.gov/wps/portal/nrcs/site/mo/home/	
Financial assistance and incentives to implement voluntary BMPs	Environmental Quality Incentives Program (EQIP) Regional Conservation Partnership Program (RCPP) Conservation Stewardship Program (CSP) Agricultural Conservation Easement Program (ACEP)
US Department of Agriculture's Farm Service Agency (FSA) https://www.fsa.usda.gov/	
Administers a program called the Continuous Sign-up Conservation Reserve Program (CCRP) that provides farmers with rental payments on land set-aside for conservation buffers for a period of 10 to15 years. Cost-share payments are also made available to help farmers with the financial burden of establishing the buffers.	Continuous Sign-up Conservation Reserve Program (CCRP)
Missouri Department of Natural Resources https://dnr.mo.gov/	
Water Protection Program https://dnr.mo.gov/water/hows-water Implements federal Clean Water Act regulations including: enforcing National Pollutant Discharge Elimination System (NPDES) regulations through point source facility operating permits, establishing Water Quality Standards, identifying impaired water bodies, and developing TMDLs.	Free volunteer water quality monitoring training and tools

Agency and Roles	Funding Options
Financial Assistance Center dnr.mo.gov/water/business-industry-other-entities/financial-opportunities/financial-assistance-center Provides technical guidance for publicly-owned treatment works and administers low-interest long-term loans to assist with technology and capacity upgrades. The Clean Water State Revolving Fund provides subsidized loans to municipalities, counties, public sewer districts, and political subdivisions for wastewater infrastructure projects. Loans may be paired with grant funds for qualifying communities. Eligible projects include new construction or improvement of existing facilities. Information on the Department's grant policy is available online at dnr.mo.gov/water/business-industry-other-entities/financial-opportunities.	Clean Water State Revolving Fund
Soil and Water Conservation Program dnr.mo.gov/env/swcp/ The Soil and Water Conservation Program (SWCP) provides financial incentives to landowners to implement practices that help prevent soil erosion and protect water quality. The program offers cost-share practices through its county conservation districts. Landowners may receive up to 75 percent reimbursement of the estimated cost of a practice through the program. The primary funding for cost-share practices from the Soil and Water Conservation Program comes from the one-tenth-of-one percent Parks, Soils, and Water Sales Tax.	SWCP cost-share
Section 319 Nonpoint Source Program dnr.mo.gov/water/what-were-doing/nonpoint-source-pollution-section-319 ▪ Provides assistance with the development of watershed-based plans and administers Section 319 subgrants for plan development and implementation.	Section 319 subgrants
Missouri Department of Conservation mdc.mo.gov/community-conservation/community-conservation-funding-opportunities/.	

Agency and Roles	**Funding Options**
Offers a number of grant and cost-share options including Community Conservation Grant and Land Conservation Partnership Grant. Provides outreach, education, and technical guidance for stream and watershed management issues. Maintains Missouri Conservation lands.	Community Conservation Grant and Land Conservation Partnership Grant Free volunteer water quality monitoring training and tools
Missouri Agricultural and Small Business Development Authority agriculture.mo.gov/abd/financial/awloanprg.php	
Offers an Animal Waste Treatment System Loan Program in cooperation with the Clean Water State Revolving Fund. Animal Waste Treatment Loans Program may finance eligible animal waste treatment systems for independent livestock and poultry producers with operations of less than 1,000 animal units. Eligible costs include storage structures, land, dedicated equipment, flush systems, composters, and more.	Clean Water State Revolving Fund
University of Missouri Extension https://extension2.missouri.edu/	
Provides guidance for farm management including crop resilience, pond health, and livestock care.	Free information and assistance
County Soil and Water Conservation Districts https://mosoilandwater.land/	
Provides guidance and assistance with the development of nutrient management plans and procurement of funding from the state cost-share program.	Free information and assistance with grant applications
Online Databases of Additional Funding Sources	
▪ Wichita State University, Environmental Finance Center (EFC) Missouri Healthy Watershed Funding Search Tool https://www.wichita.edu/academics/fairmount_college_of_liberal_arts_and_sciences/hugowall/efc/news/meramec-funding-sources-landing-page.php ▪ Catalog of Federal Funding https://www.epa.gov/waterdata/catalog-federal-funding ▪ EPA Nonpoint Source Funding Opportunities http://water.epa.gov/polwaste/nps/funding.cfm ▪ Environmental Justice Grants https://www.epa.gov/environmentaljustice/environmental-justice-grants-and-resources ▪ Grants.gov http://www.grants.gov	

10. Conclusion

The ultimate goal of this TMDL implementation strategies document is to restore the impaired streams to conditions that meet Missouri Water Quality Standards through the protection of whole-body contact recreation. Implementation strategies should follow an adaptive management approach that makes progress toward achieving water quality goals while using new data and information to reduce uncertainty and adjust implementation activities. Implementation efforts are expected to occur over a number of years, but within the schedules established in state operating permits and watershed-based plans. Success in achieving water quality standards will be determined by the Department through biennial assessments of water quality compliance as required by Sections 305(b) and 303(d) of the federal Clean Water Act.

11. References

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Appendix A
Nine Key Elements Critical to a Watershed-Based Plan

a. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan, as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).
b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).
c. A description of the nonpoint source management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.
d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, U.S. Department of Agriculture's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.
e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.
f. A schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.
g. A description of interim, measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.
h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a nonpoint source TMDL has been established, whether the nonpoint source TMDL needs to be revised.
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Appendix B
Potential Participants and Roles in Implementation

The Department implements TMDL targets for point sources through the Missouri State Operating Permit program. For nonpoint sources, private landowners and citizen groups voluntarily implement water quality improvement projects and cost-share practices, which may be funded in part by grants or subgrants from the Department's Section 319 Nonpoint Source Implementation Program and the Soil and Water Conservation Program. Local governments, citizen groups, and individuals who have an interest in improving water quality in their communities may implement additional water quality improvement actions. Successfully meeting the goals of a TMDL often requires participation and cooperation from various parties within a watershed. Participant roles range from technical support to actual on-the-ground implementation of BMPs. Groups and agencies that may potentially be involved in the TMDL implementation process are identified below along with descriptions of their possible roles. This list is not exhaustive and not intended to compel participation from any organizations; nor is it meant to exclude those who are not listed, but may be interested in participating.

- Department of Natural Resources
    - Administers statutory authorities granted by Missouri clean water law
    - Ensures permits issued in the watershed are consistent with the assumptions and requirements of TMDL wasteload allocations (the allowable point source load) o Provides compliance assistance to regulated entities
    - Provides technical support to locally-led watershed groups
    - Serves as a potential source of financial assistance for watershed plan development and BMP implementation through Sections 319(h) and 604(b) grants, or through Soil and Water Program cost-share practices
    - Serves as a potential source of financial assistance for infrastructure improvements through low-interest State Revolving Fund loans
    - Assesses attainment of water quality standards on a biennial basis for Clean Water Act Sections 303(d) and 305(b) reporting Implementation Strategies
    - Provides education and training to volunteers through the Missouri Stream Team Program
    - Provides technical assistance for market-based approaches to compliance such as water quality trading
- County Soil and Water Conservation Districts
    - Provide financial incentives to agricultural producers to implement conservation practices that help prevent soil erosion and protect water quality
    - Provide technical assistance with design, implementation, and maintenance of conservation practices
- University of Missouri Extension
    - Provides technical assistance for addressing nonpoint source and watershed management issues
    - Assists with organizing locally led watershed groups
- Missouri Department of Conservation
    - Provides technical assistance with stream and watershed management issues

    - Promotes maintenance and reestablishment of stable streambanks and functional riparian corridors
- Missouri Department of Health and Senior Services
    - Provides technical assistance pertaining to onsite wastewater treatment systems (i.e., septic)
- County Health Departments
    - Provide technical assistance pertaining to onsite wastewater treatment systems
- Locally led watershed groups
    - Develop and implement Section 319-funded nine key element watershed-based plans (See Appendix A)
    - Identify critical areas at a local level
    - Implement BMPs to reduce nonpoint source pollutant loading
    - Provide public education and outreach
- Stream Team volunteers
    - Collect screening level water quality data (i.e., dissolved oxygen and biological monitoring) through the Volunteer Water Quality Monitoring program
    - Provide stewardship, advocacy, and education.

Appendix C
Nutrient Load Duration Curves for the Grand River Watershed

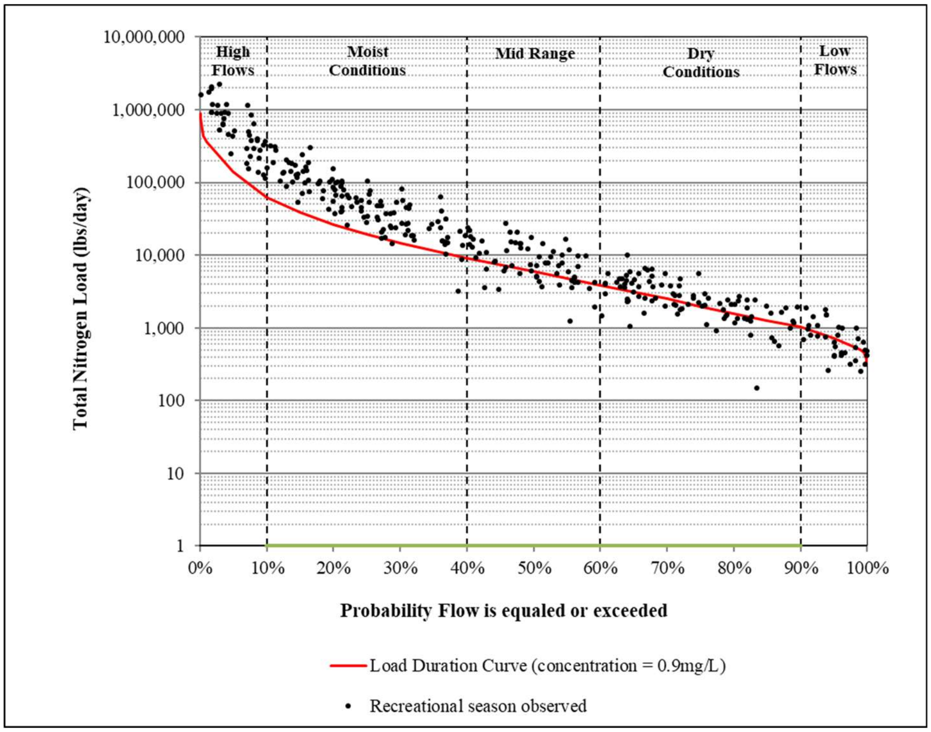

Figure 1C. Total Nitrogen Load Duration Curve for the Grand River (WBID 593)

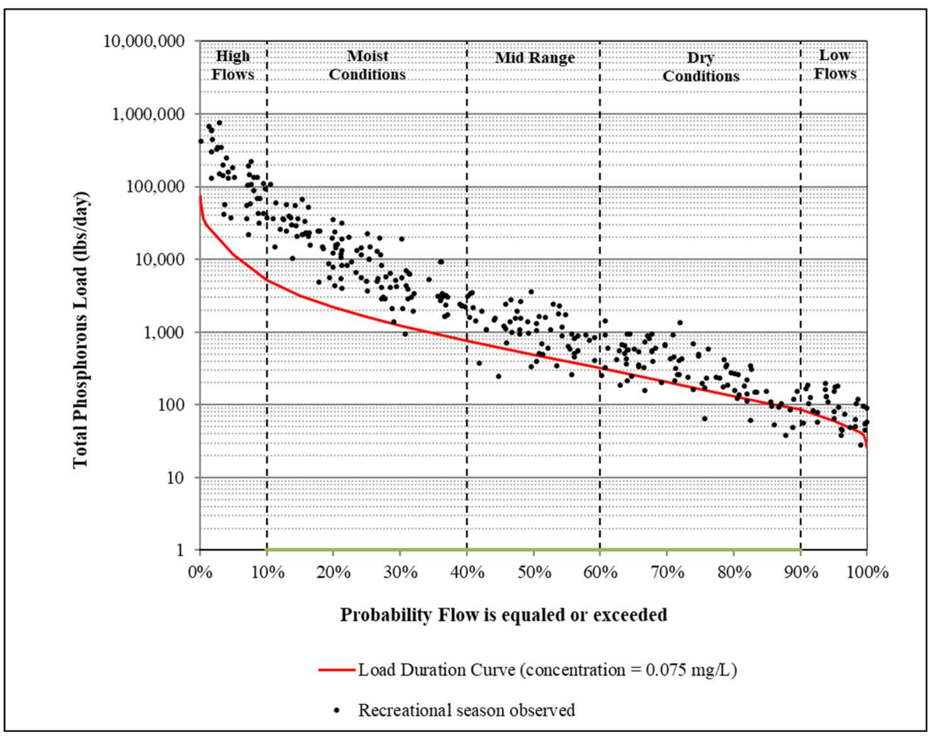

Figure 2C. Total Phosphorous Load Duration Curve for the Grand River (WBID 593)

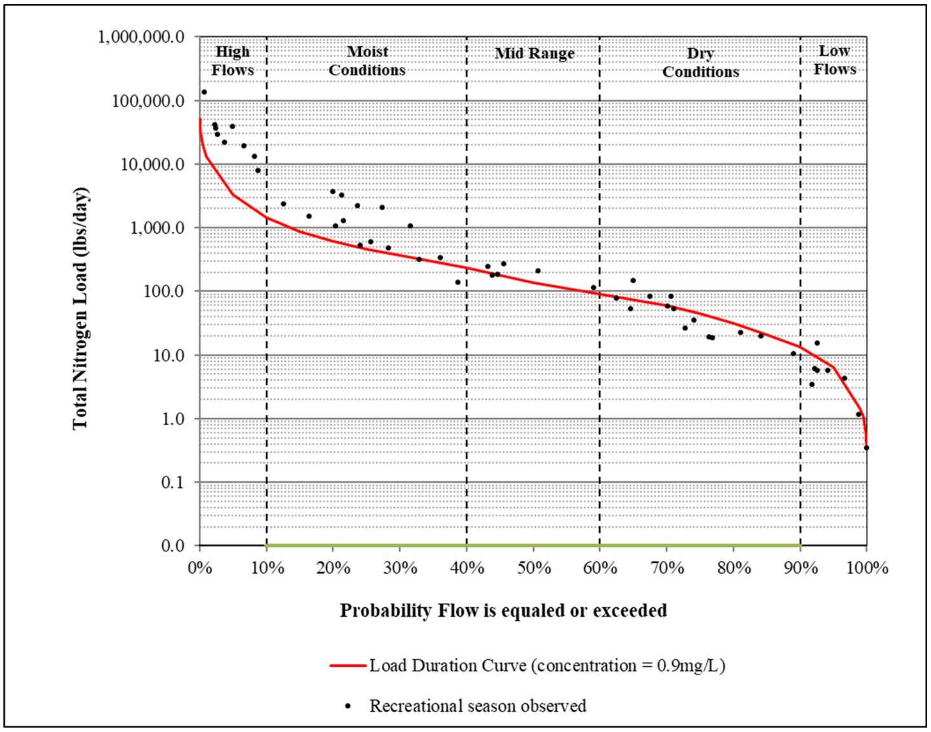

Figure 3C. Total Nitrogen Load Duration Curve for the Middle Fork Grand River (WBID 468)

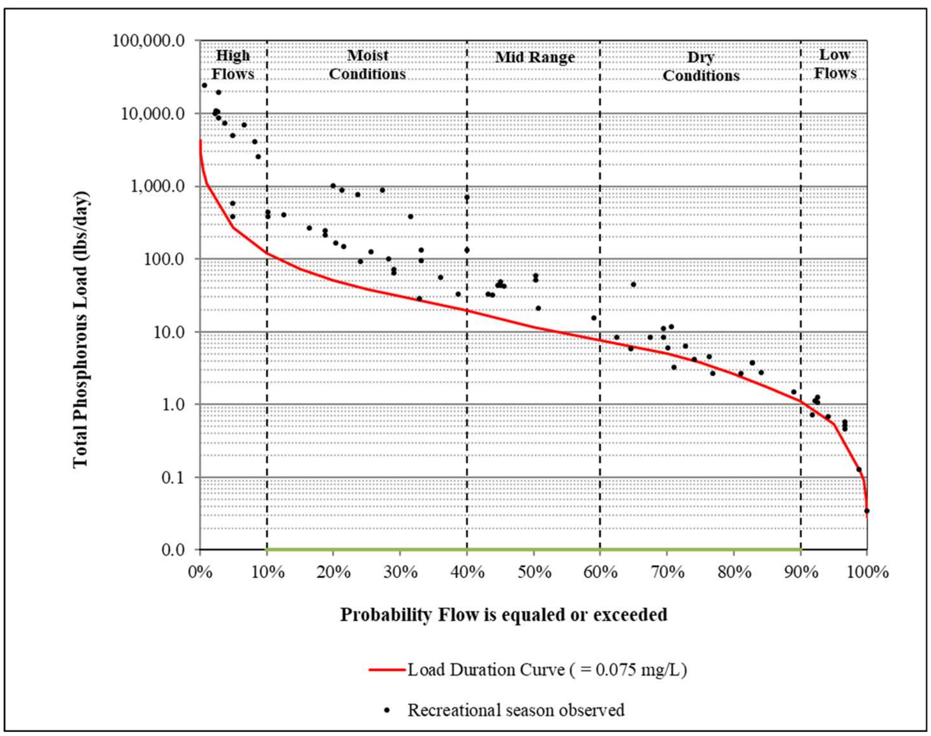

Figure 4C. Total Phosphorous Load Duration Curve for the Middle Fork Grand River (WBID 468)

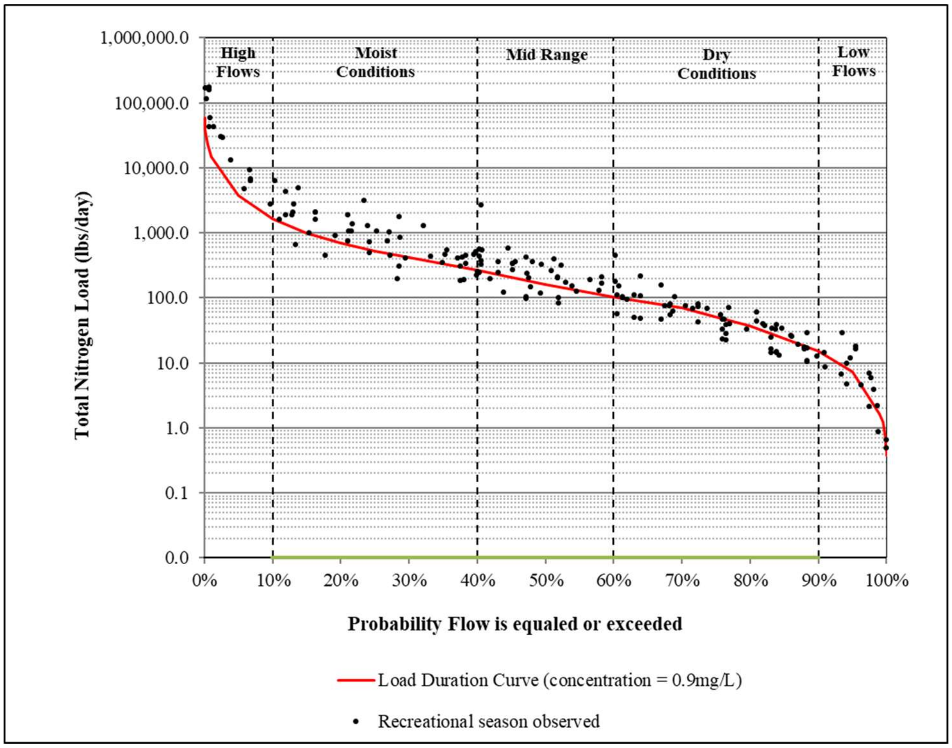

Figure 5C. Total Nitrogen Load Duration Curve for Locust Creek (WBID 606)

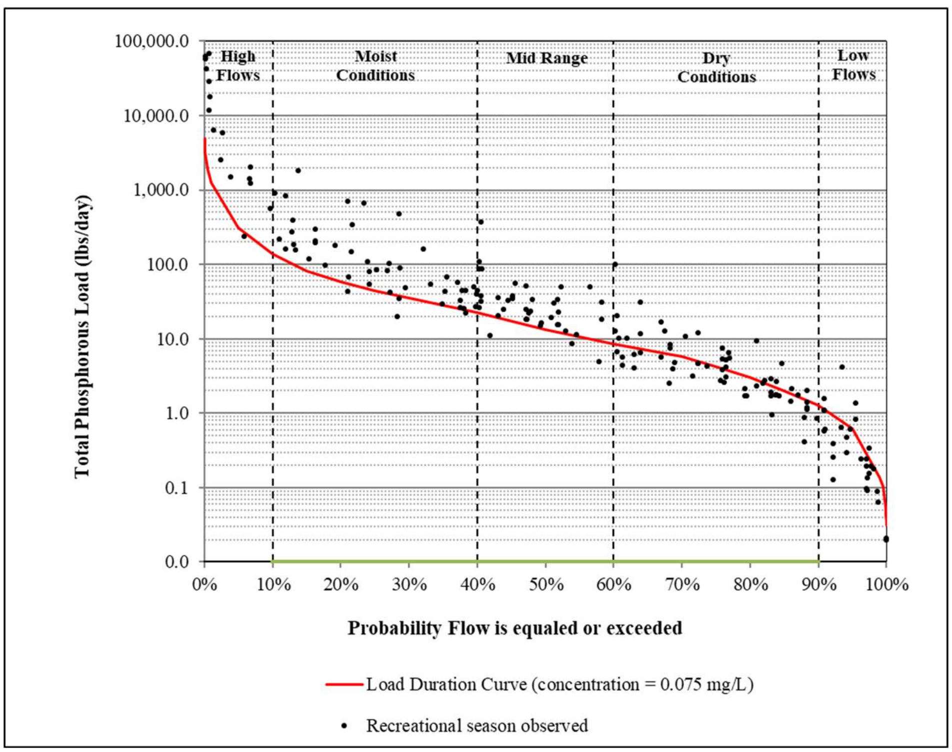

Figure 6C. Total Phosphorous Load Duration Curve for Locust Creek (WBID 606)

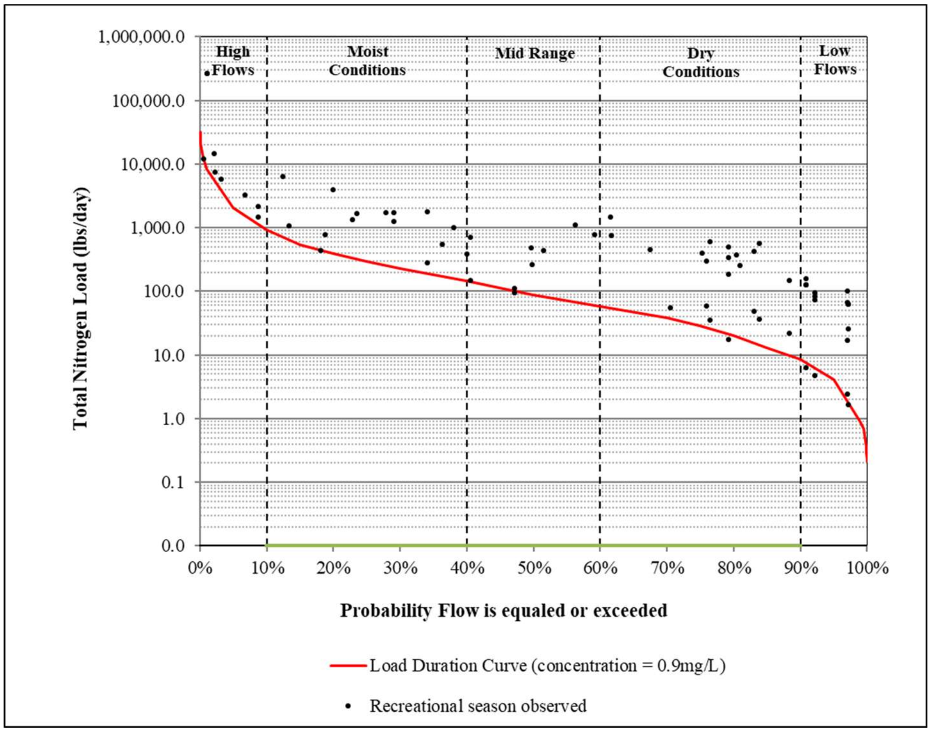

Figure 4C. **Total Nitrogen Load Duration Curve for East Fork Locust Creek (WBID 608, 610)**

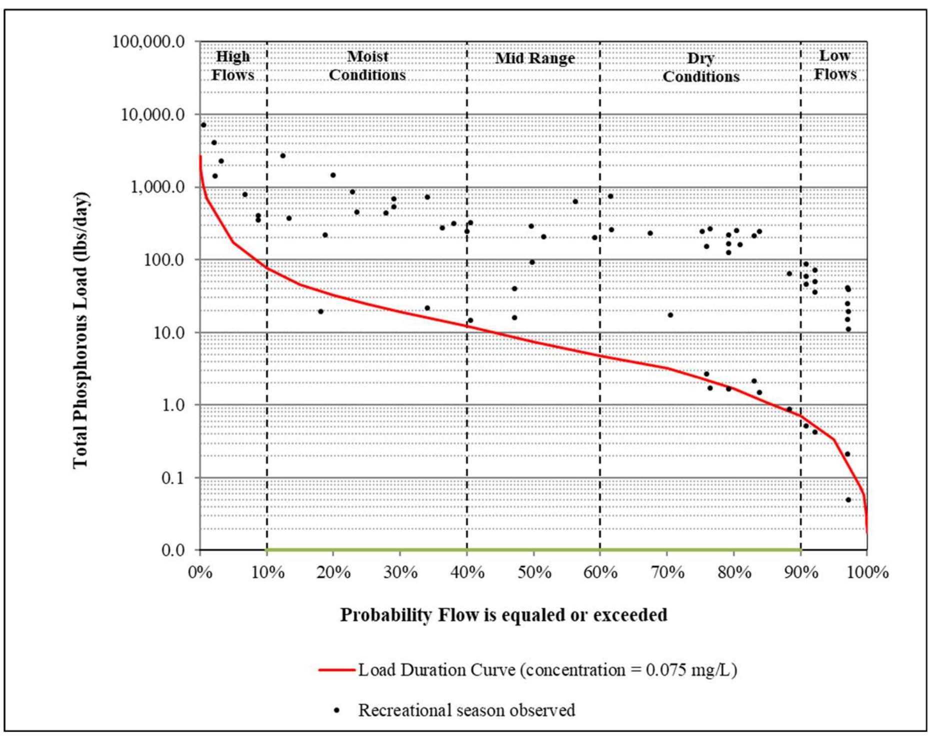

Figure 8C. Total Phosphorous Load Duration Curve for East Fork Locust Creek (WBID 608, 610)

Appendix D
Estimated Nutrient Reductions for Establishing Reduction Targets

Missouri's water quality standards do not establish nutrient criteria for streams. However, nutrient load reductions are a statewide priority, and many of the nonpoint source management measures that reduce *E. coli* loading also reduce nitrogen and phosphorus loading. Excessive nitrogen and phosphorus loading can contribute to excessive algae growth causing low oxygen levels in surface water that impairs aquatic life and contributes to bad tasting drinking water (NRCS 2013).

Nutrient targets used for load duration curves are based on RTAG benchmark values (Appendix C). These benchmark values are expected to be protective of Missouri's designated uses, but are not water quality criteria codified in Missouri's Water Quality Standards regulations at 10 CSR 20-7.031. In the absence of Missouri specific nutrient criteria for streams, these targets are provided only as guidance to assist watershed planning activities. The Grand River, Middle Fork Grand River, East Fork Grand River, Locust Creek, and East Fork Locust Creek are not currently identified as impaired due to nutrients and no specific nutrient reduction is required for attainment of existing applicable water quality standards. Groups developing their own watershed plans may determine that alternative, scientifically defensible, nutrient targets are more appropriate. If a TMDL is developed in the future to address nutrient pollution in Grand River, Middle Fork Grand River, East Fork Grand River, Locust Creek, or East Fork Locust Creek then the load allocations established in that approved TMDL should serve as the targets for watershed planning and nonpoint source nutrient reduction efforts.

Tables 10 and 17 summarize the nitrogen and phosphorous loads the Grand River, Middle Fork Grand River, East Fork Grand River, Locust Creek, and East Fork Locust Creek at selected flows. Nutrient data for East Fork Grand River were unavailable so reductions were not estimated. The load reductions were calculated based on the 95th percentile of observed total nitrogen and total phosphorous that exceeded the RTAG recommendation of 0.9 milligram per liter (mg/L) of total nitrogen and 0.075 mg/L total phosphorous. Load duration curves for total nitrogen and total phosphorus are included in Appendix C.

Total Nitrogen Loads and Recommended Reductions for the Grand River

Percent of Time Flow Is Equal or Exceeded	Flow Condition	Median Flow (cfs)	Target Load (lbs/day)	Existing Load (lbs/day)	Needed Reduction (lbs/day)	Needed Reduction (%)
100-90	Low Flow	149.50	725.76	1,607	882	54.9%
90-60	Dry Conditions	407.10	1,976.31	5,796	3,819	65.9%
60-40	Mid Range	1,219.00	5,917.76	20,753	14,835	71.5%
40-10	Moist Conditions	3,993.38	19,386.24	190,139	170,752	89.8%
10-0	High Flow	28,750.00	139,569.75	1,956,836	1,817,266	92.9%

Total Phosphorous Loads and Recommended Reductions for the Grand River

Percent of Time Flow Is Equal or Exceeded	Flow Condition	Median Flow (cfs)	Target Load (lbs/day)	Existing Load (lbs/day)	Needed Reduction (lbs/day)	Needed Reduction (%)
100-90	Low Flow	149.50	60.48	1,607	1,547	96.2%
90-60	Dry Conditions	407.10	164.69	5,796	5,631	97.2%
60-40	Mid Range	1,219.00	493.15	20,753	20,260	97.6%
40-10	Moist Conditions	3,993.38	1,615.52	190,139	188,523	99.2%
10-0	High Flow	28,750.00	11,630.81	1,956,836	1,945,205	99.4%

Total Nitrogen Loads and Recommended Reductions for the Middle Fork Grand River

Percent of Time Flow Is Equal or Exceeded	Flow Condition	Median Flow (cfs)	Target Load (lbs/day)	Existing Load (lbs/day)	Needed Reduction (lbs/day)	Needed Reduction (%)
100-90	Low Flow	1.32	6.42	12	6	47.6%
90-60	Dry Conditions	9.26	44.96	107	62	58.1%
60-40	Mid Range	28.62	138.92	266	127	47.7%
40-10	Moist Conditions	95.06	461.48	3,419	2,958	86.5%
10-0	High Flow	676.20	3,282.68	98,978	95,696	96.7%

Total Phosphorous Loads and Recommended Reductions for the Middle Fork Grand River

Percent of Time Flow Is Equal or Exceeded	Flow Condition	Median Flow (cfs)	Target Load (lbs/day)	Existing Load (lbs/day)	Needed Reduction (lbs/day)	Needed Reduction (%)
100-90	Low Flow	1.32	0.54	1.2	0.67	55.4%
90-60	Dry Conditions	9.26	3.75	16.7	12.94	77.6%
60-40	Mid Range	28.62	11.58	390.9	379.35	97.0%
40-10	Moist Conditions	95.06	38.46	878.0	839.54	95.6%
10-0	High Flow	676.20	273.56	21,336.4	21,062.81	98.7%

Total Nitrogen Loads and Recommended Reductions for Locust Creek

Percent of Time Flow Is Equal or Exceeded	Flow Condition	Median Flow (cfs)	Target Load (lbs/day)	Existing Load (lbs/day)	Needed Reduction (lbs/day)	Needed Reduction (%)
100-90	Low Flow	1.51	7.34	20	12	63.0%
90-60	Dry Conditions	10.58	51.38	158	106	67.4%
60-40	Mid Range	32.70	158.76	560	402	71.7%
40-10	Moist Conditions	108.64	527.40	3,968	3,441	86.7%
10-0	High Flow	772.80	3,751.63	169,284	165,533	97.8%

Total Phosphorous Loads and Recommended Reductions for Locust Creek

Percent of Time Flow Is Equal or Exceeded	Flow Condition	Median Flow (cfs)	Target Load (lbs/day)	Existing Load (lbs/day)	Needed Reduction (lbs/day)	Needed Reduction (%)
100-90	Low Flow	1.51	0.61	1.3	0.68	52.7%
90-60	Dry Conditions	10.58	4.28	14.2	9.92	69.9%
60-40	Mid Range	32.70	13.23	77.1	63.88	82.8%
40-10	Moist Conditions	108.64	43.95	695.7	651.74	93.7%
10-0	High Flow	772.80	312.64	56,412.5	56,099.91	99.4%

Total Nitrogen Loads and Recommended Reductions for East Fork Locust Creek

Percent of Time Flow Is Equal or Exceeded	Flow Condition	Median Flow (cfs)	Target Load (lbs/day)	Existing Load (lbs/day)	Needed Reduction (lbs/day)	Needed Reduction (%)
100-90	Low Flow	0.84	4.06	135	131	97.0%
90-60	Dry Conditions	5.86	28.44	765	736	96.3%
60-40	Mid Range	18.10	87.89	959	871	90.8%
40-10	Moist Conditions	60.14	291.96	4,773	4,481	93.9%
10-0	High Flow	427.80	2,076.80	268,079	266,003	99.2%

Total Phosphorous Loads and Recommended Reductions for East Fork Locust Creek

Percent of Time Flow Is Equal or Exceeded	Flow Condition	Median Flow (cfs)	Target Load (lbs/day)	Existing Load (lbs/day)	Needed Reduction (lbs/day)	Needed Reduction (%)
100-90	Low Flow	0.84	0.34	75.7	75.41	99.6%
90-60	Dry Conditions	5.86	2.37	269.2	266.83	99.1%
60-40	Mid Range	18.10	7.32	493.9	486.56	98.5%
40-10	Moist Conditions	60.14	24.33	1,891.0	1,866.68	98.7%
10-0	High Flow	427.80	173.07	135,161.4	134,988.35	99.9%

Appendix E
Priority Riparian Corridor Location Maps

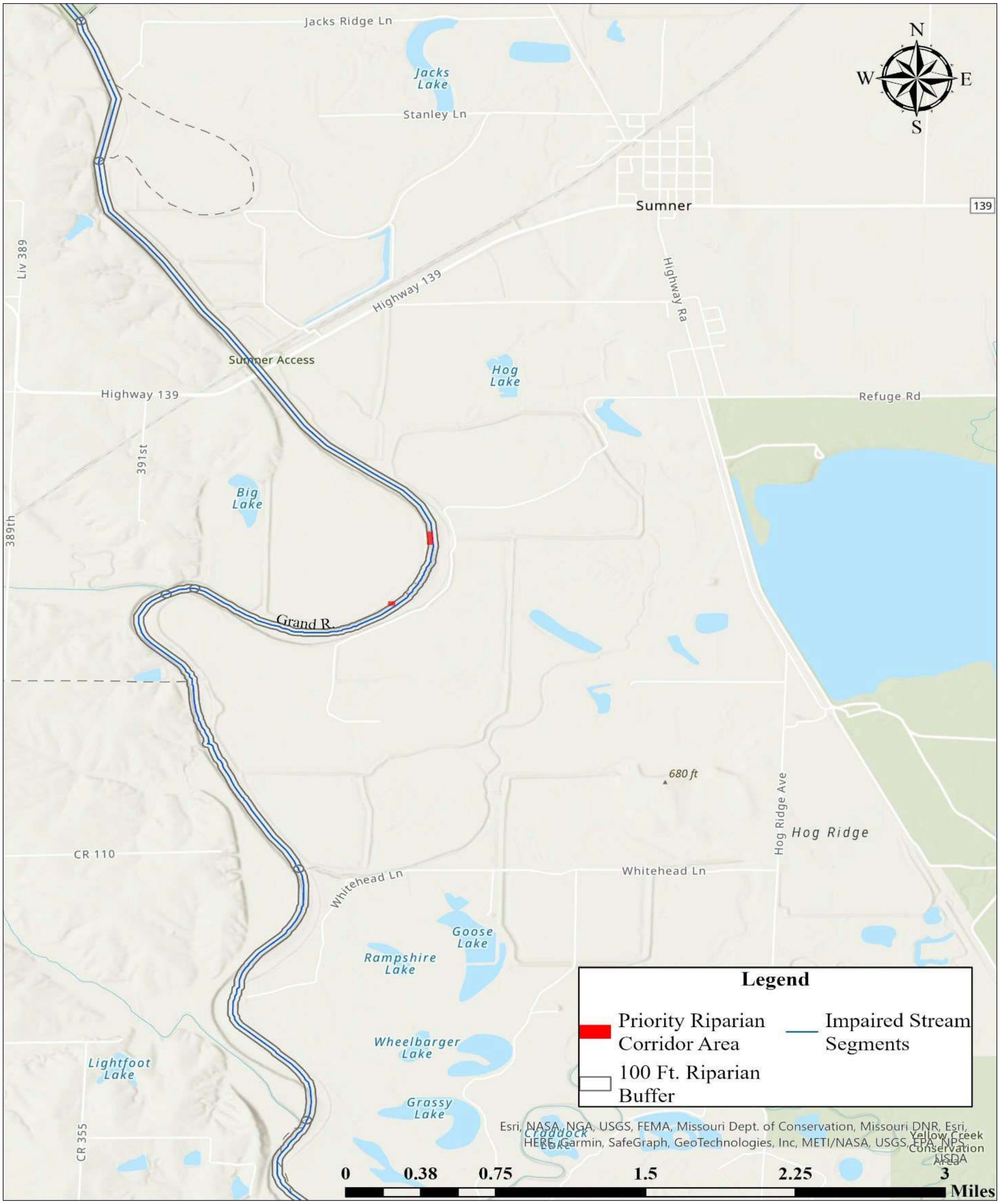

Figure 5D. Central Grand River (WBID 593) priority riparian corridor locations

Figure 6D. Upper Middle Fork Grand River (WBID 468) priority riparian corridor locations

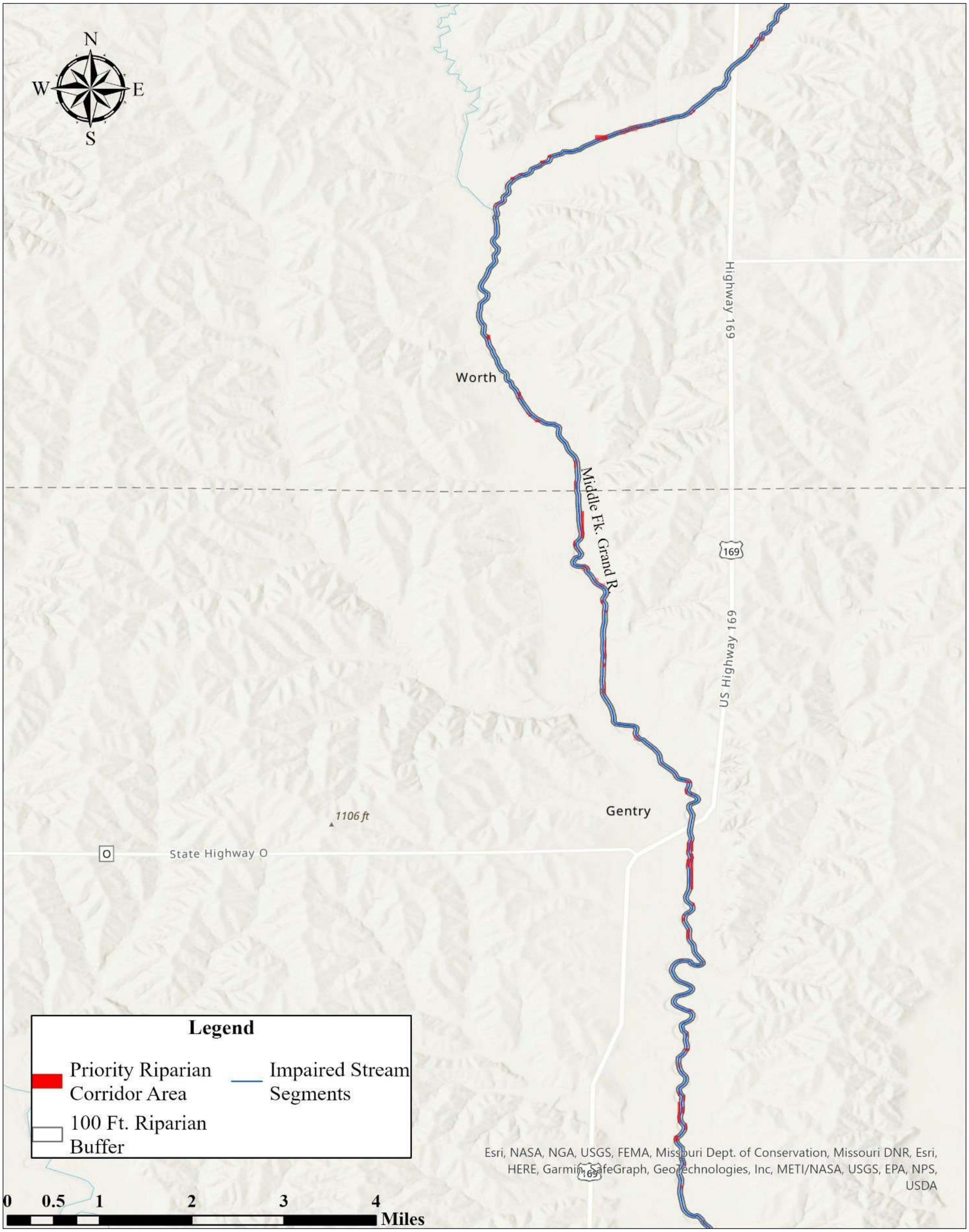

Figure 7D. Central Middle Fork Grand River (WBID 468) priority riparian corridor locations

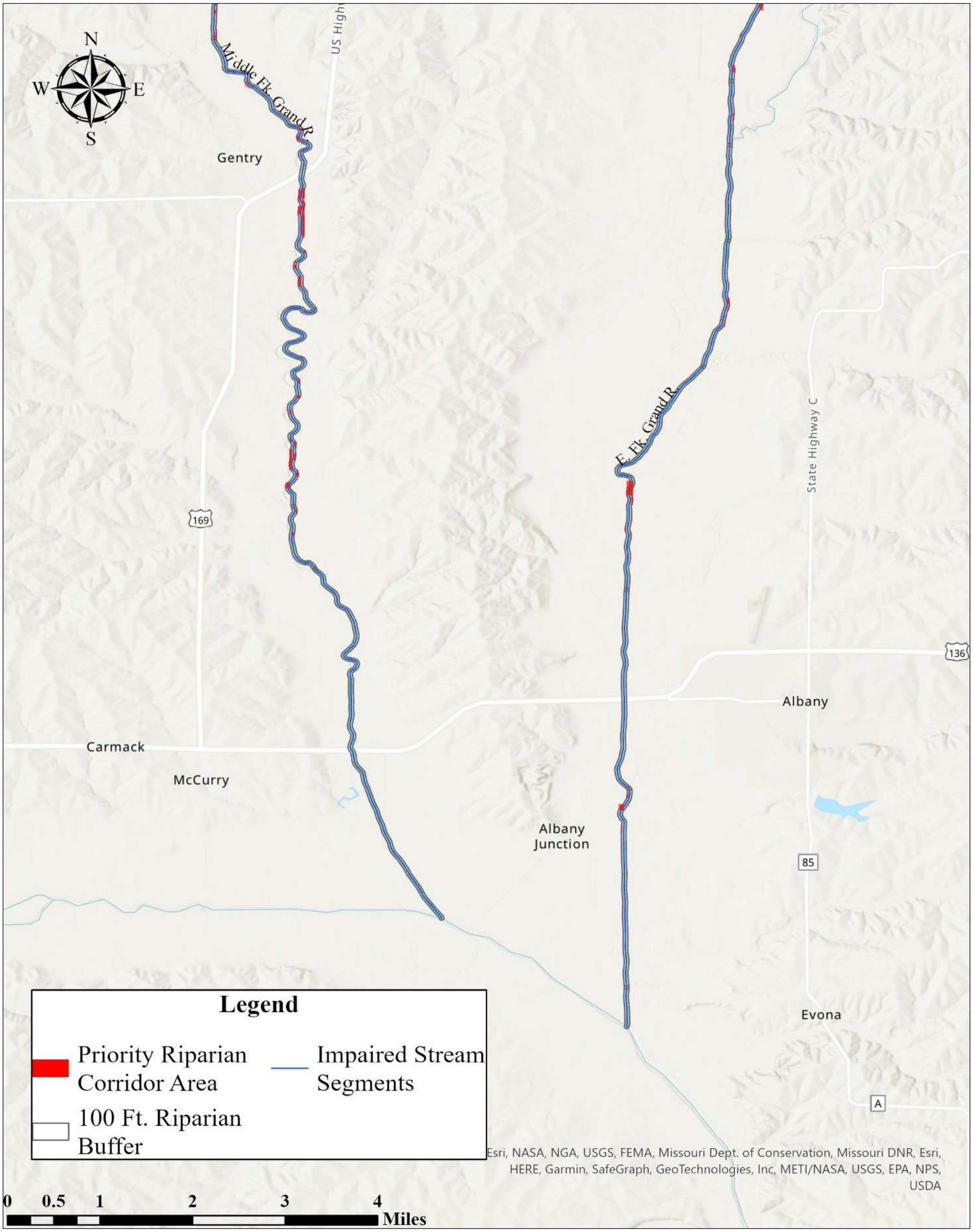

Figure 8D. Lower Middle Fork Grand River (WBID 468) and Lower East Fork Grand River (WBID 457) priority riparian corridor locations

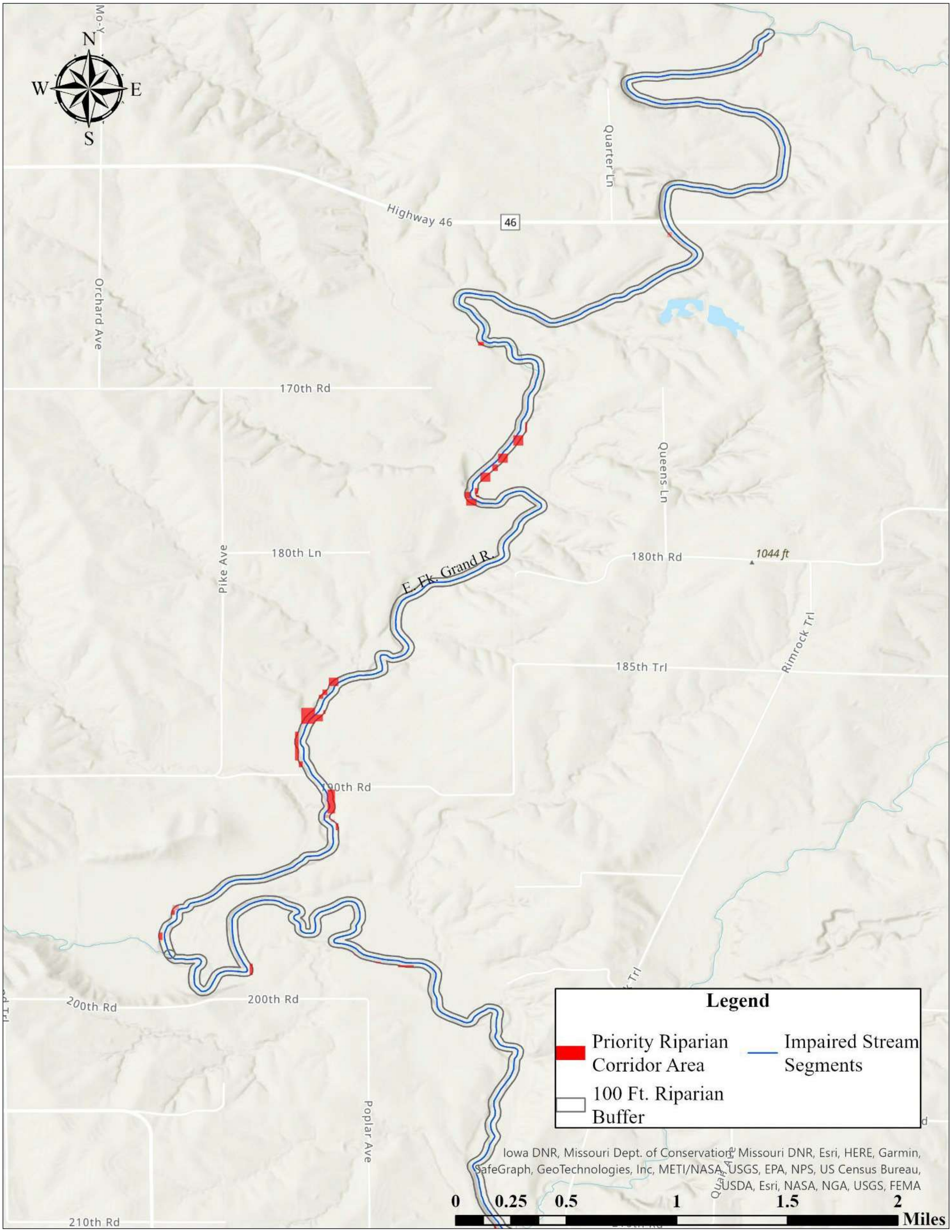

Figure 9D. Upper East Fork Grand River (WBID 457) priority corridor riparian locations

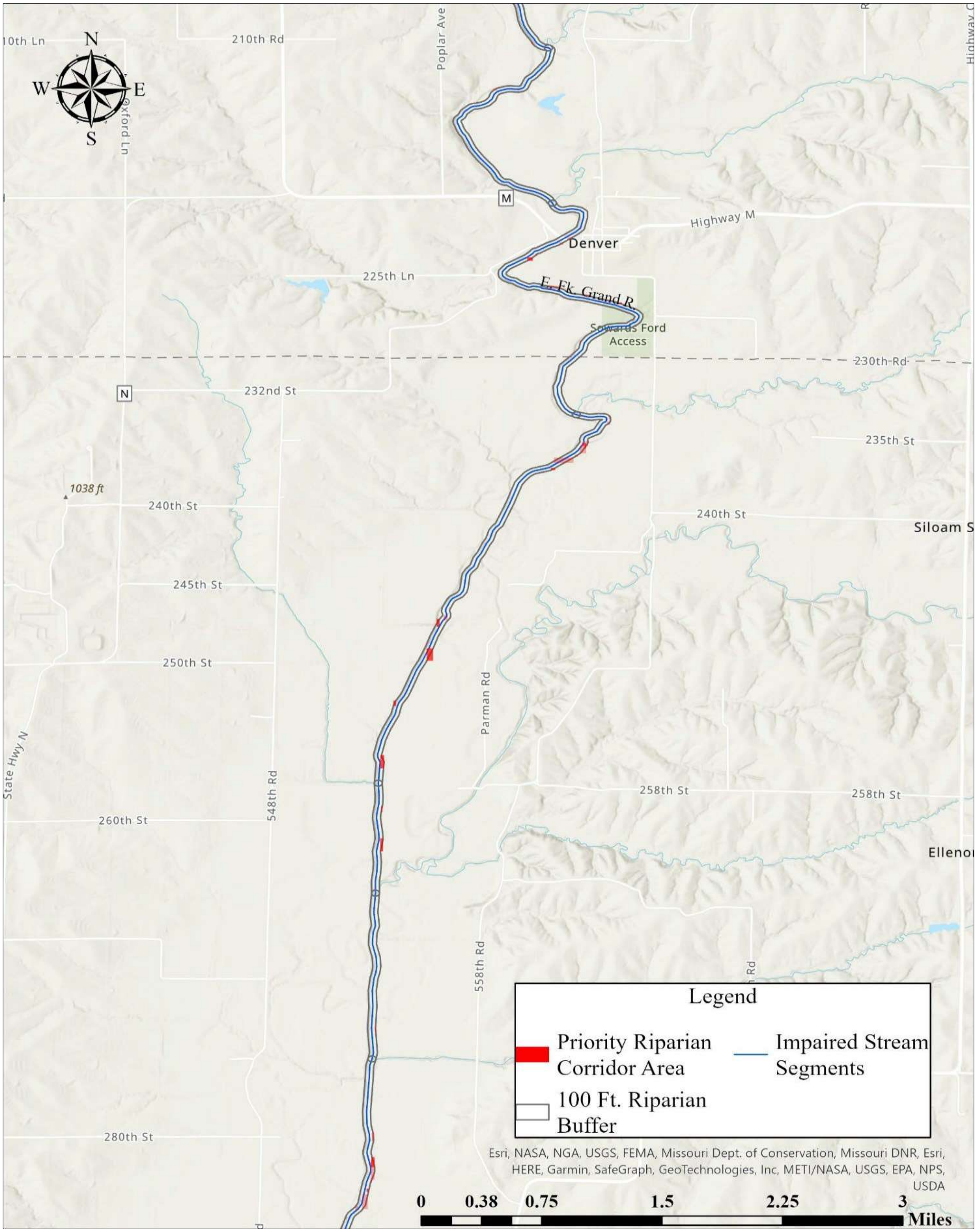

Figure 10D. Central East Fork Grand River (WBID 457) priority riparian corridor locations

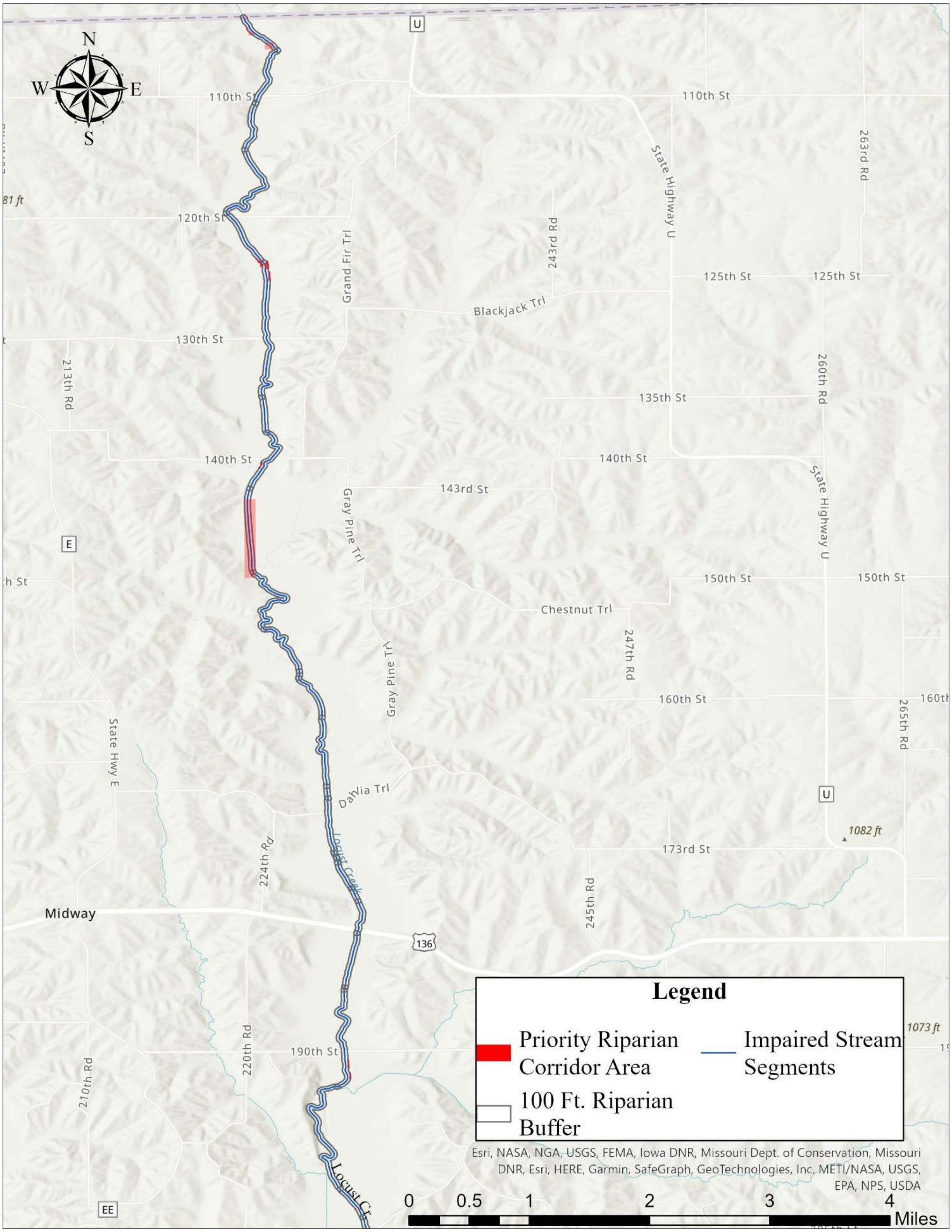

Figure 11D. Upper Locust Creek (WBID 606) priority riparian corridor locations

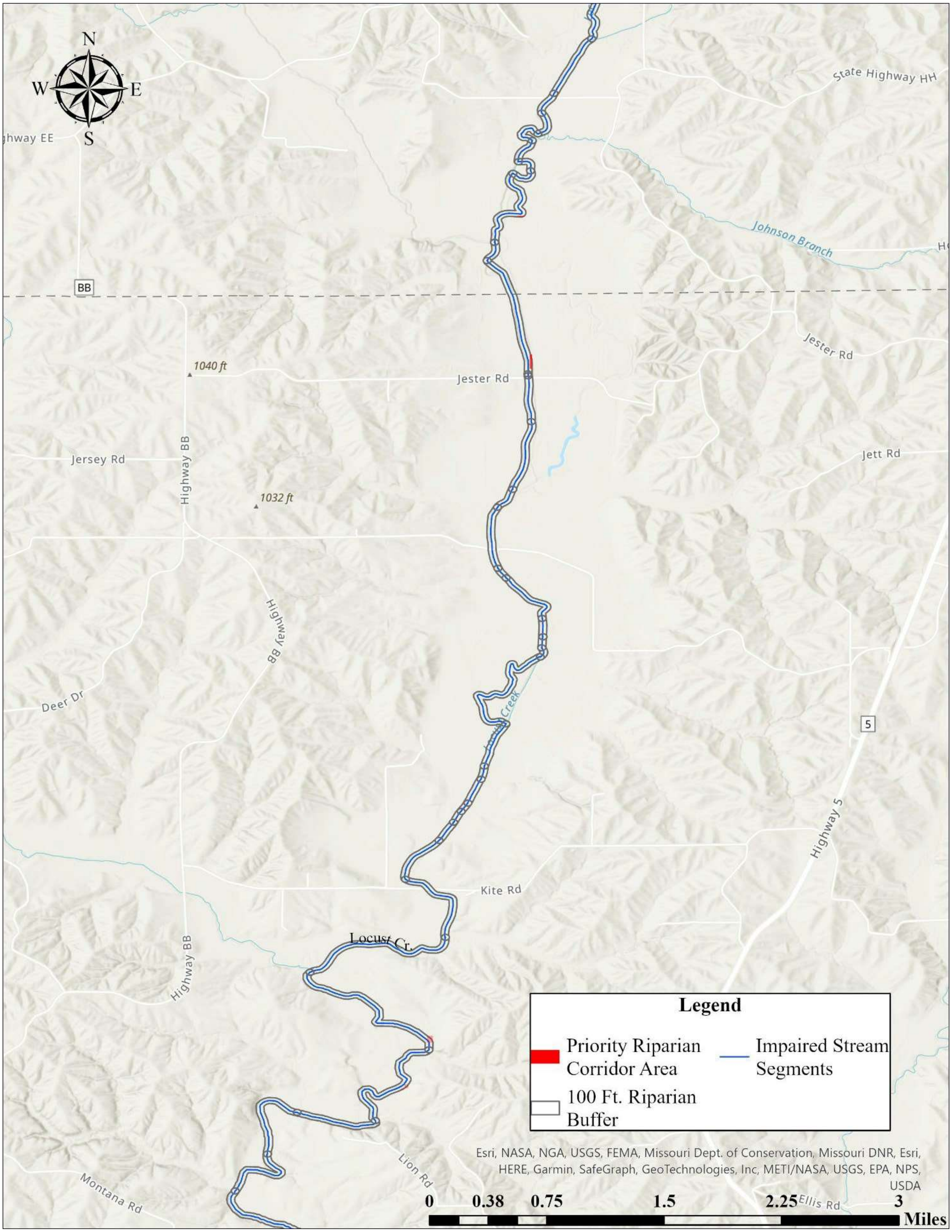

Figure 12D. Central Locust Creek (WBID 606) priority riparian corridor locations

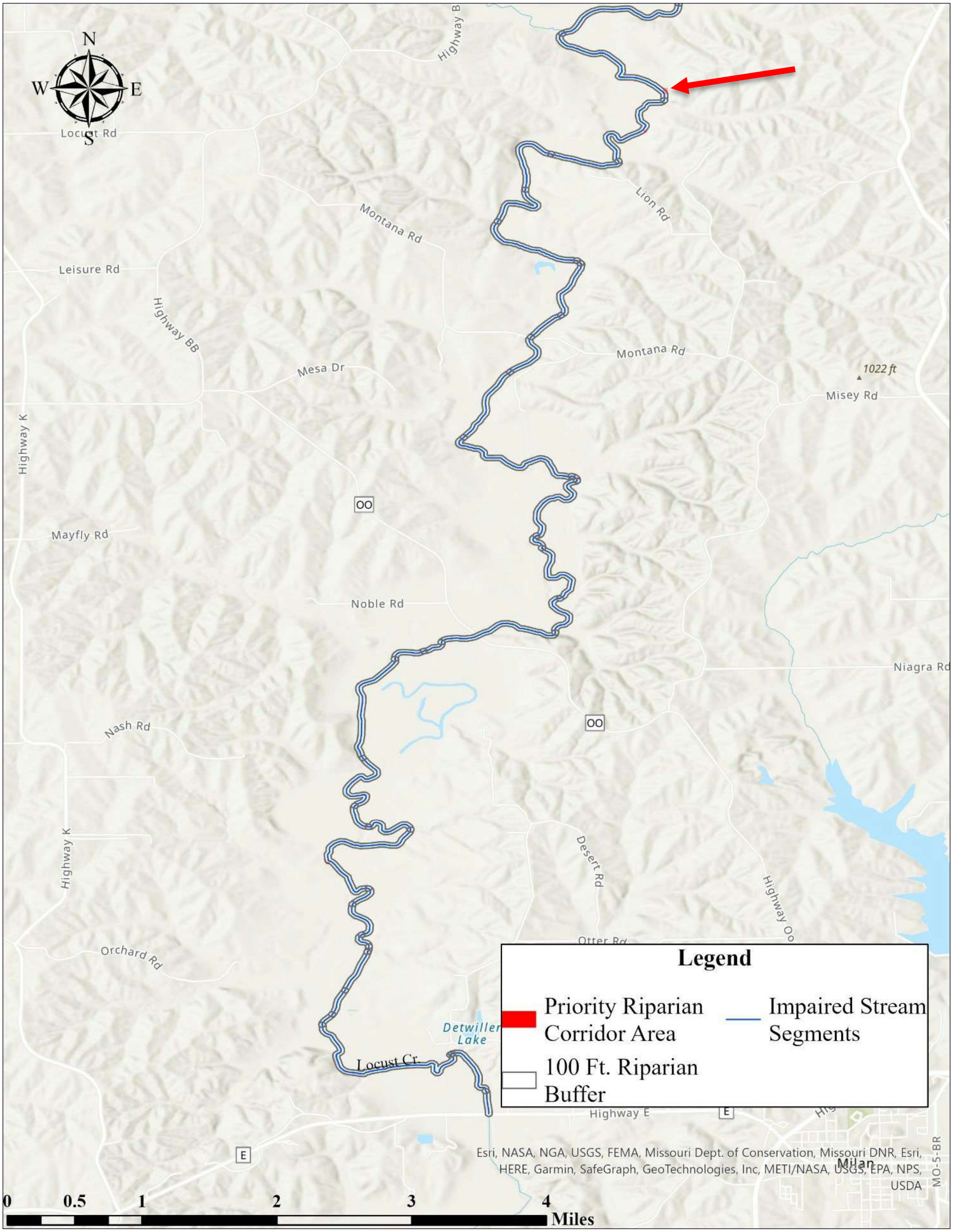

Figure 13D. Lower Locust Creek (WBID 606) priority riparian corridor locations

Figure 14D. Upper East Fork Locust Creek (WBIDs 608,610) priority riparian corridor locations

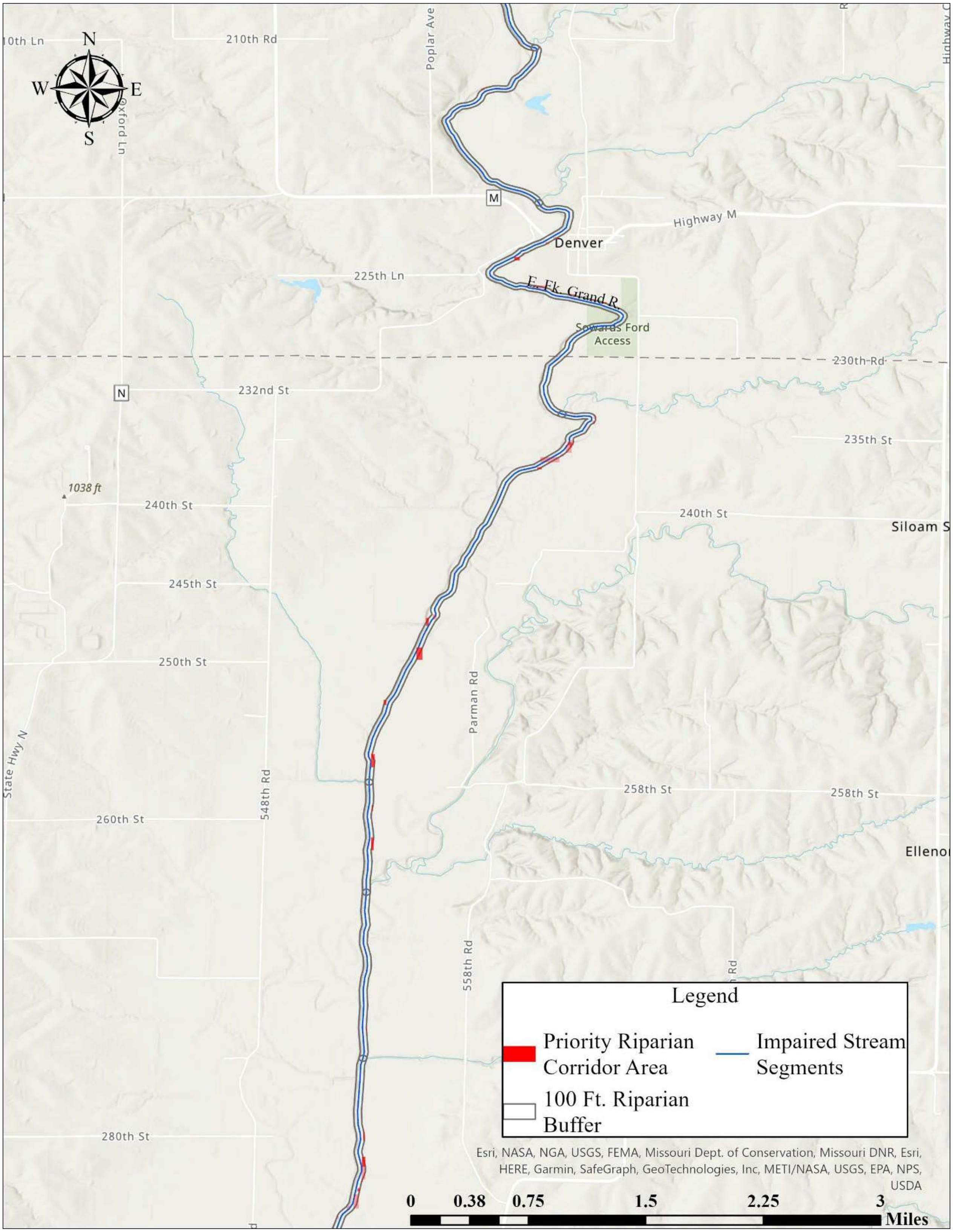

Figure 15D. Central East Fork Locust Creek (WBIDs 608,610) priority riparian corridor locations

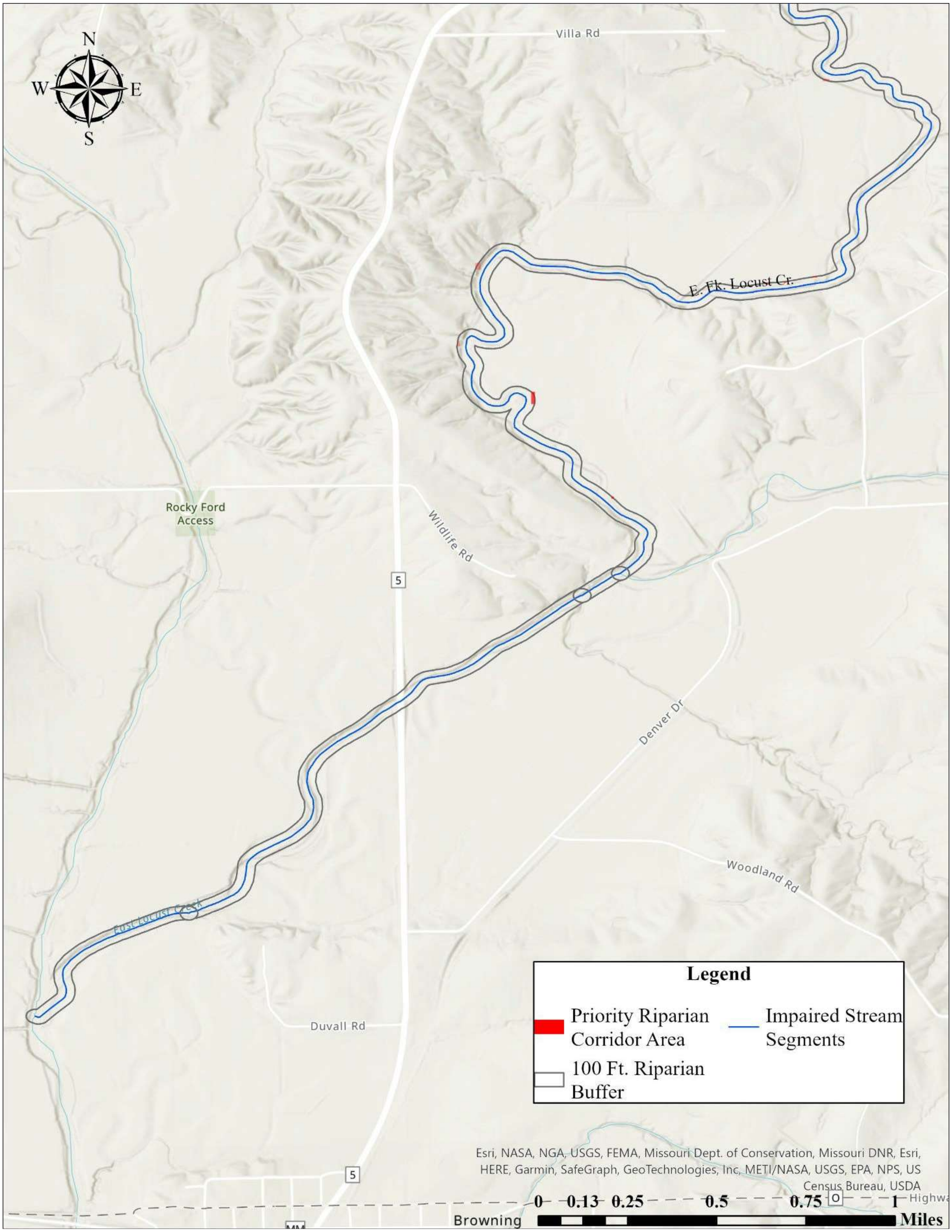

Figure 16D. Lower East Fork Locust Creek (WBIDs 608,610) priority riparian corridor locations